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• Drilling and Producing • Refining and Petrochemical • Oil and Gas Pipelining

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Pursuing Those Phantom Billions

THE oil industry, in its relation with the government and the public, is confronted at times by tossed-off figures that may come from a slide-rule but have little contact with reality.

Remember when the Federal-States dispute shut down operations in the never-called marginal sea? At that time those favoring Federal control conjured $40 billion worth of oil being given to three states; then without a field being discovered the price rose to $100 billion in the headlines.

Who finds these figures? Apparently they were snatched from the sea and written in the sky; they were flipped into air waves and smeared into headlines. Did they mean anything? Could they be proved?

The power of huge attention-compelling sums is that they seem to convert a complex problem into a simple statement of addition and subtraction, understood by those who have no time to seek more information. They tempt advocates by their expediency.

Our latest billion-dollar figure comes from the oil-producing industry's perennial critic, Paul E. Hadlick, general counsel of the National Oil Marketers Association. He is discussing an old hate of his — the depletion allowance — and has come up with a new argument — a billion dollars. A "true" depletion allowance, he states, instead of the present one, would yield the U. S. government an **additional one billion dollars annually.**

You may be able to dig out figures on oil production and taxes to add up to one billion dollars with no depletion allowance but you would have to go to fantastic lengths to do it. Federal tax returns from oil-producing income is presently far under a billion dollars. How could a tax on the 27½ per cent now exempt by the depletion allowance add a billion dollars?

If you were out to collect that billion, however, your best chance would be to make the legislation retroactive. After one look at a tax that allows them little chance of financing new drilling to replace the fields they are depleting, most operators would cut exploration as soon as possible. They couldn't afford to risk the capital necessary for 9-to-1-shot wildcats. They would continue to develop known fields where there is less risk and look for a less hazardous business.

This very human reaction (which doesn't translate into exact figures) immediately affects the **$1.4 billion** paid by the industry for leases and royalties and the **$6 billion** paid for equipment and services (in 1952). It is bound to cut down the **$3.5 billion** paid to industry employees (the largest portion goes to drilling and producing workers) and it will be an unfavorable influence on employment and income in supply and service companies.

Nobody knows how deep this cut in drilling and production would be. Like any figure in our economic system — the human equation prevents any hard and fast prediction. But cancelling the depletion allowance could easily cost more than the phantom billion dollars it is supposed to bring in.

The inference, also, that the oil industry would itself pay a billion dollars is false. Right now the oil industry collects about **$5 billion** a year from its customers and turns it over to Federal, state, and local governments. If cancelling the depletion allowance should bring another $1 billion to the government it would, of course, *be collected from consumers.* Where do people get the idea the oil industry has magic money of its own? Every cent the industry pays for operating expenses, for financing, for payrolls, and for taxes comes from the customers who buy its products.

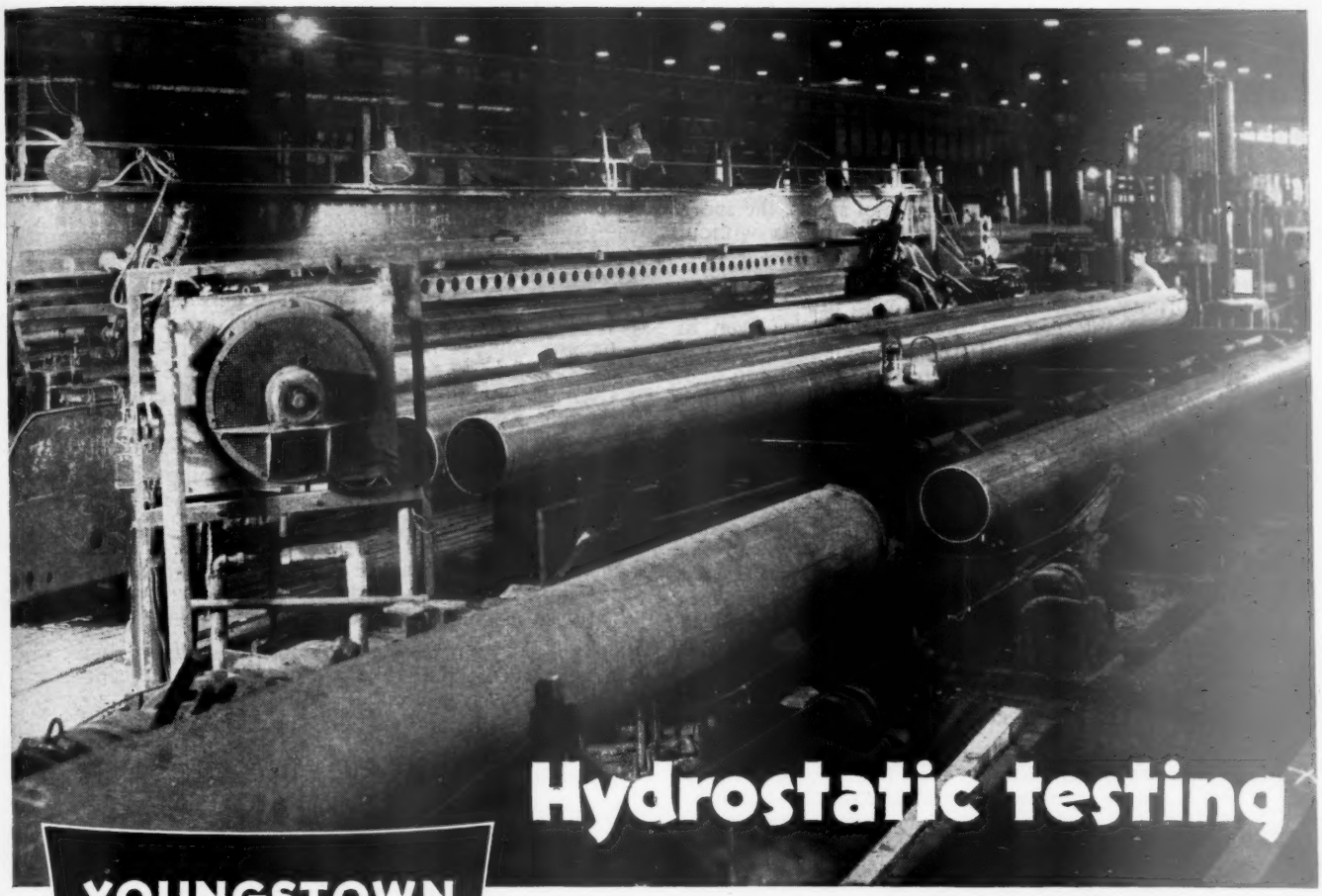
And what about imports? Wouldn't this doubly encourage imports and put the finishing touches to that vital segment of the industry — the small companies and the individual operators — which finds 75 to 80 per cent of U. S. new reserves each year?

The 27½ per cent depletion allowance (limited to 50 per cent of net income from the producing properties) may not be a perfect solution. There are rare instances when it works too favorably for the operator and others when it hurts the operator. But in covering a wide range of conditions the results have been of practical value. Because a soldier with 20 children is an expensive proposition for Uncle Sam's Army, should we stop allowances for all children of service men?

Different opinions on the depletion allowance are valid but in respect for the human "X" in our economic equations let's stop slinging billions all over the place.

No one denies the allowance has had a substantial part in making this country the leading nation in oil output and consumption. It has been an incentive to the producer and has helped keep prices low. Right now our strength and our safety rest in large measure upon our oil production and potential. That one fact is worth much more than any phantom billion dollars. —*Ernestine Adams*

XUM



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With the EDITORS

The Three-Legged Tripod of Industry

The "family row" over division of spoils, the spoils of industry and the income thereform is without doubt most far-reaching controversy, tug-of-war, dog-fight or what-have-you in the present and immediate past history of the human race, with the possible exception of international political quarrels. Even in that case the industrial Eternal Triangle is more completely continuous, without truce or interruption than *any* other. Now comes a single, small voice in the wilderness, sounding a "new" note the simplicity of which makes us wonder why it has not been shouted from the housetops long ago.

The "voice crying in the wilderness" is that of Wladimir Woytinsky, author-economist, who points out in his report "Employment and Wages in the United States" (Published by Twentieth Century Fund, New York), that neither stockholders, management, or labor deserve any special consideration in cutting the cake of income from industrial or commercial operations in which all take part, and that the split should be three-way.

Woytinsky observes that increases in productivity generally run parallel to advances in mechanization of industry, mechanization paid for by capital or by profits from operations, mechanization that calls for less physical effort and less mental concentration on the part of the worker. Similarly, management is not due special consideration for carrying out its proper and normal job of obtaining and using better and better equipment for its operations, therefore does not deserve a special cut of the "pie." And in the same vein, the author does not believe capital, the stockholders who make capital available to obtain and pay for the improved equipment and methods are due any lion's share.

The Tripod of industry agree in general with the author's idea that all agreements on division of profits should be arrived at through "unrestrained, uncoerced bargaining," in opposition to a Federal agency lording it over all three, as has been the case in recent years of socialistic government. Labor leaders attempt to excuse and justify their wage-raising pressure by saying that this pressure is responsible for forcing management, and capital suppliers, to utilize improved processes, methods and equipment to keep down unit labor costs and thus continue to be able to make profits—and pay dividends of course.

On this we are reminded of the story of the ants marooned on the log floating down the flood-rampaging river, each of which thought he was steering the log.—A. L. F.

OCC Order "Roundabout" Approach

A recent order by the Oklahoma Corporation Commission, on the surface, raises questions of legality. The order, which declares "no pipe line company purchasing or transporting less than the amount fixed by the order shall be allowed to purchase or transport oil in Oklahoma," has created an unusual situation.

Apparently, the purpose is to assure producers that every drop of oil produced and offered to a pipe line will be taken, regardless of circumstances.

Pipe lines are divided into two categories: Common carriers, required by federal and state laws, to accept all crude offered even if it must be taken "ratably"; and private carriers, who transport crude for exclusive use of the company operating the pipe line.

Interstate pipe lines operating as common carriers do not "purchase" oil in the sense of crude marketers, but on a contractual basis by which it replaces only that amount of oil that is removed from its line at various destinations. Purchasers of crude from producers "sell" or transfer title to their oil to the pipe lines, and take a like amount under the same title from the pipe line's "common stock" at a terminal up the line. By doing this, they are able to avoid delay in deliveries and tie-up of large amounts of capital.

Another point: The capacity of a pipe line's "inventory" (amount of oil needed to fill the line initially, which must be maintained) is limited. Pipe lines are not balloons — they can't be expanded or contracted at will. Most pipe lines have some tank storage. When this storage is full, and the line is full — that's all. It is physically impossible to add more.

For every barrel of crude put into the line, a barrel must be taken out. In order to be able to accept as much oil as is offered, it is necessary to have some place to put the oil being displaced by new shipments.

Buyers of crude, however, are not taking as much oil because of oversupply. Efficient operation demands that inventories remain within certain limits.

As a result of too much supply and not enough demand, buyers cannot make purchases as large as previously. Consequently, pipe lines are not transporting as much oil as previously.

The Oklahoma Corporation Commission order in one respect, is quite plain in language, though: Take all we offer or you cannot take any.

The OCC order does not apply to other forms of transportation. Railroads and truckers are not affected. The order is directed solely at pipe line companies.

What about private carriers? Pipe lines, operated as plant facilities of purchasers and refiners, are bearing the load of the order, when in reality the order is aimed at the purchasers.

The same is true of the common carriers. Pipe line companies, acting under the laws of the state and nation, are merely transporters, not marketers.

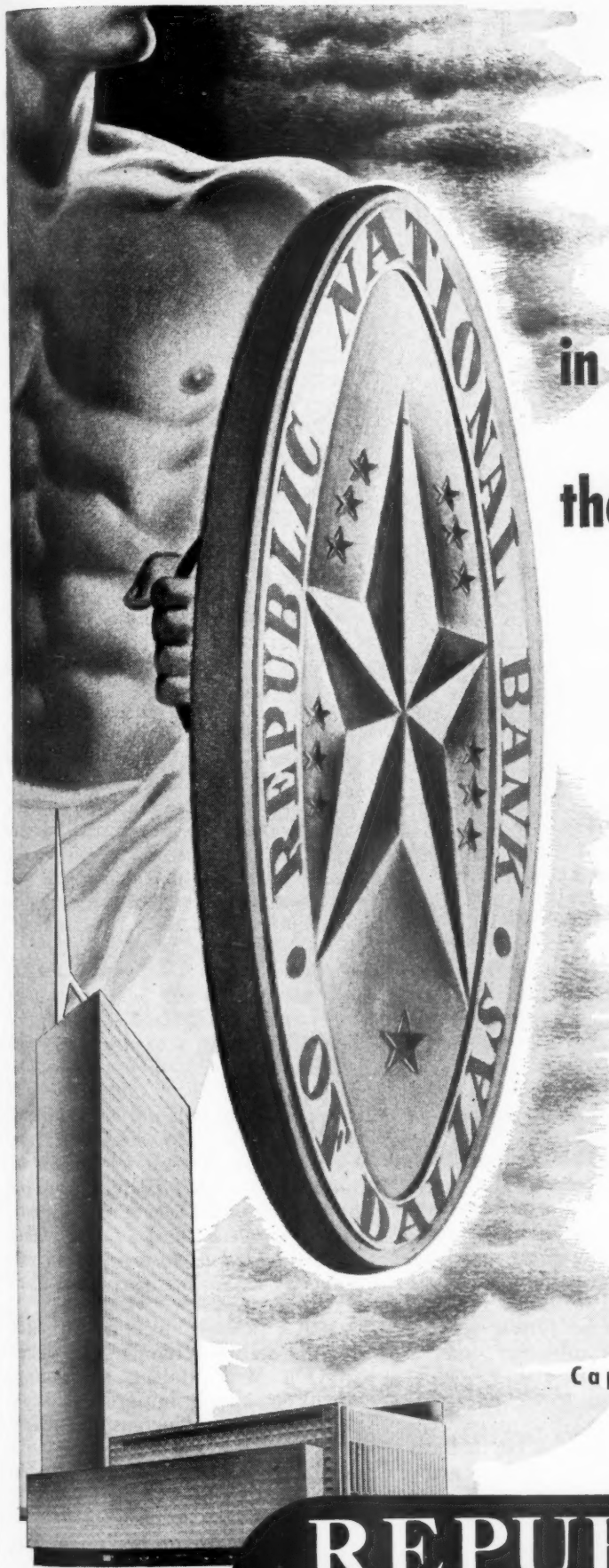
Whenever supplies exceed purchasers' demands, some form of "proration" is necessary. During such times, pipe lines prefer to take crude requirements from leases already connected rather than make additional connections. This is only logical. Pipe lines must be operated efficiently and economically.

Observers have noted in the past that many of the complaints lodged against pipe line companies, should lie at the door of the crude oil *purchaser*, not the pipe line company, which is solely a *transporter*.

The reason for directing the order at the pipe line companies is not entirely clear. Unless the members of the Oklahoma commission are totally uninformed on crude purchasing operations, pipe line operations, state and federal statutes, and the natural laws of supply and demand, the order is quite unreasonable.

A legal test would seem to be indicated. Until the pipe line companies bring court action, determination of the order's legality can merely be opinion. Inasmuch as the order is for only a two-month period, court action may not be justified. The order may set a dangerous precedent, though, which would have consequences much more far-reaching. — D. H.

XUM



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HIGHLIGHTS IN OILDOM

Standard California cuts imports . . . Socony-Vacuum president warns more foreign oil will be needed in future . . . Price question confused . . . Heselton confronts industry worried by oversupply with threat to renew investigations if shortage appears . . .

The oil industry will not be able to "keep up" if prices are cut, said Dr. Robert H. Wilson, board chairman of Standard Oil of Indiana. He added that the government's "insistent urging for development of excess capacity has left the industry with the stuff running out of its ears," but emphasized that overproduction was only four or five per cent.

★ ★ ★

Robert G. Dunlop, president of Sun Oil Company, urged price reductions as a means of ending an oversupply of oil. He called for a reduction of prices "all the way down the line from the service station to the oil fields." Price reductions would result in an increase in consumption, he stated, would stimulate interest in improving efficiency, and would make the importation of crude oil and products less attractive.

★ ★ ★

Representative Heselton is threatening the industry with further investigations if there is a fuel oil shortage this winter. Heselton has made his threat in reply to a statement by Frank M. Porter, president of API, who said there was nothing wrong with the glutted market that a good cold winter wouldn't cure. Heselton said if a hard winter results in shortages of fuel oil anywhere in the country, congressional hearings will be renewed.

★ ★ ★

The Office of Defense Mobilization turned down an application for a storage project recently recommended by PAD. Site of proposed location of the storage project, Baltimore, Maryland, did not meet government's plant dispersion requirements, set up to keep strategic facilities out of heavily-concentrated areas. This was the first request for rapid tax amortization recommended by PAD and turned down by ODM.

★ ★ ★

Tonnage of crude oil and natural gas produced in the U. S. in 1952 was greater than that of any other single commodity, L. F. McCollum, Continental Oil president, revealed at an Oil Progress Week luncheon. "Only the tonnage of coal even came close to matching the amount of oil and gas produced last year," McCollum reported. "Most of us think of steel and iron ore as being produced in tremendous volume, but the tonnage of oil and gas in 1952 was two and a half times as great as that of iron ore and steel."

★ ★ ★

B. Brewster Jennings, president of Socony-Vacuum, says that this country needs a steady and increasing supply of foreign oil. He pointed out the U. S. "uses more than 60 per cent of the free world's production, but has only about 25 per cent of the free world's oil reserves." Jennings said that in the next 20 years the industry would have to find a billion barrels more oil a year than it has since World War II to maintain domestic reserves in their present ratio to production. He warned the industry not to "forfeit our rights to foreign oil to solve a temporary oversupply."

★ ★ ★

General Electric has reported a 29 per cent increase in gross income for the first 9 months this year over same period last year. Sales totaled $2,341,048,000, highest nine-months' level in company's history. Net income also increased, all of which prompted President Ralph J. Cordiner to say he saw nothing in this picture to justify fears of a recession!

★ ★ ★

Twenty special articles dealing with geology, drilling, refining, pipe line activities, and other phases of the oil industry in Oklahoma will be featured in December's The Petroleum Engineer. *Feature articles cover two hot spots in exploration, exciting secondary recovery plans and projects, and methods that improve both exploration and drilling. Do you know Oklahoma has produced more oil per acre than any other state?*

★ ★ ★

Herbert Hoover, Jr., State Department petroleum advisor is in Tehran, Iran, for a series of conferences with Iranian leaders. Before going over, Hoover appealed to oil state authorities to fit Iranian oil into the oil picture without increasing U. S. imports from the Middle East.

Standard Oil of California will curtail imports into California because past critical shortages have now been met. President T. S. Petersen said fourth quarter imports will be cut 15,000 bbl a day, to be followed early in 1954 by a decrease of about 9000 bbl daily. Import rates in second and third quarter were 54,000 bbl a day. Petersen added imports were being continued a sufficient rate to offset shortage of California crude available to the company to meet its markets.

★ ★ ★

There is nothing the oil industry needs like a good cold winter. Not abnormally cold, just the type winter weather the country used to experience. This would take care of all oversupply, oil men declare.

★ ★ ★

Industry has a human interest and an economic stake in employee health and is finding it good business to do something constructive about it, James H. Pipkin, vice president of The Texas Company, believes. Pipkin said that "human assets, even though they cannot appear in any financial statement, are of far greater value than the physical assets (of companies) which would soon depreciate were it not for personnel."

★ ★ ★

Petroleum enterprises abroad amounted to nearly $4½ billions at the end of 1952, the Department of Commerce has estimated. Foreign oil investment grew by $1 billion from 1950 to 1952, and at the end of 1952 represented about 30 per cent of total U. S. foreign investments. Main interest in foreign oil since 1950 seems to have been centered in Canada where it was estimated about a third of the billion dollars added to foreign oil investments by U. S. firms was used.

★ ★ ★

IPAA leaders meeting in Fort Worth recently, commended Standard Oil of California for cutting down on its oil imports. Officials pointed out that increasing oil imports since August had resulted in a total of 1,261,600 bbl daily rate for the week October 3.

★ ★ ★

Phillips Petroleum has a new deep well in the upper Gulf Coast, setting a depth production record in that area. Well is No. 1 Hullen, which flowed from 14,549-81 ft. Another reflection of the trend to deeper and deeper wells.

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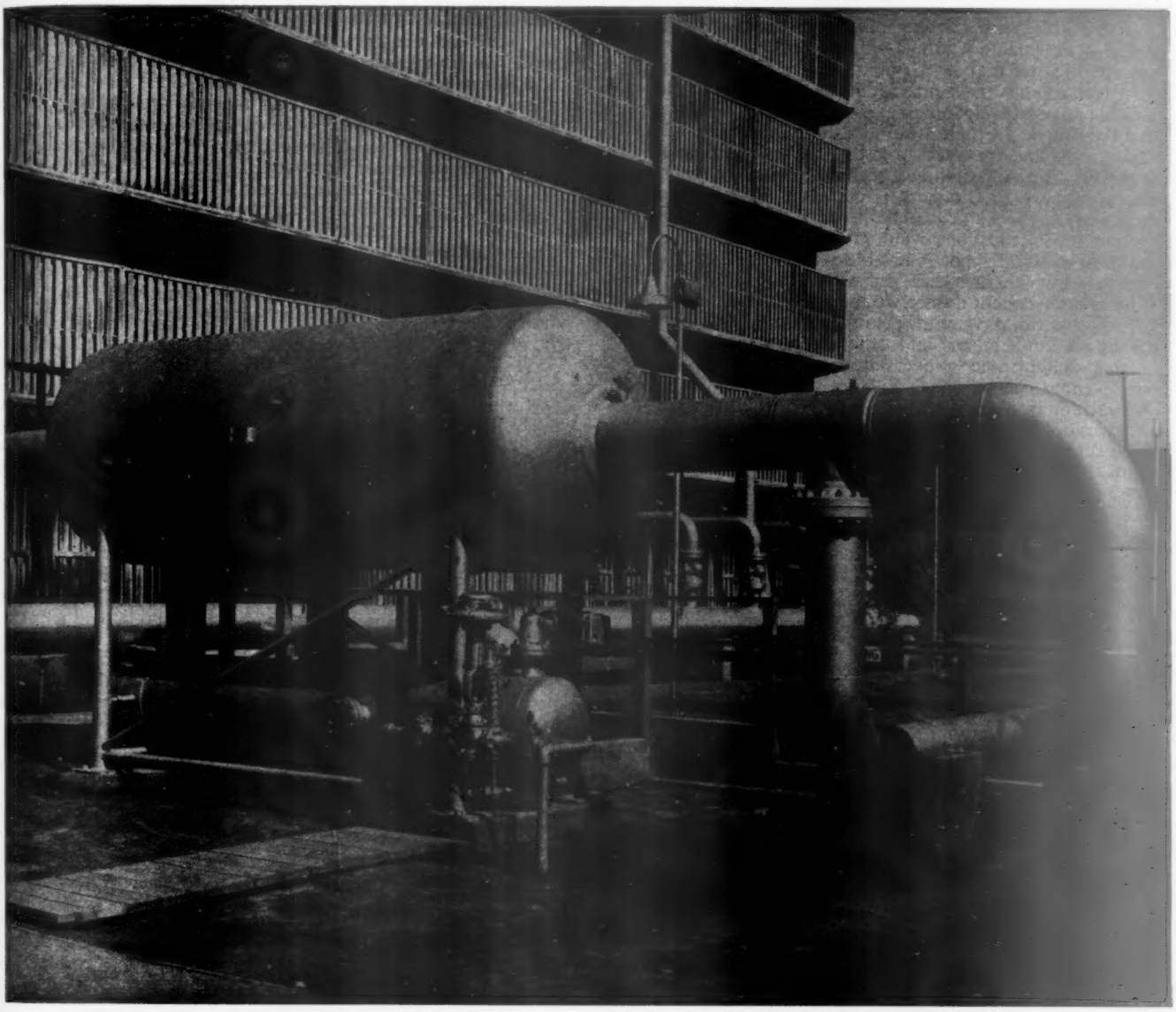

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DICK SNEDDON

MISSOURI GIN RUMMY CHAMPIONSHIP

The other evening while we were hovering about the Los Angeles Petroleum Club, seeking whom we might devour, metaphorically, that is, a pair of interesting looking gentlemen walked into the game room, accompanied by Don McKenzie, a lad of Caledonian extraction who is tightly attached to Fred Currie's Copperweld Company. Presently Fred himself arrived and we discovered that the two gentlemen aforesaid were none other than Lou Mathy, vice president of the Key Company, St. Louis, Missouri, and Bart Braznell, chief engineer of the same estimable institution. Thereafter we spent a most enjoyable evening, first, engaging in a spirited joust of vessel, skipper, and able seamen, a speculative pastime from which Don emerged with a nice stash of matches.

Over an excellent dinner we then had a most elevating discussion that ran the gamut from martial preparedness to marijuana, via euphemisms and other literary tish-tosh, and out of this delightsome conversational binge, we further discovered that our St. Louis visitors were both well informed and extremely pleasant people. Towards the heel of the evening we took the Missourians mildly to camp in a gin rummy game and because of this outstanding feat have a mind to claim the gin championship of Missouri.

Anyway, in toto, as the lawyers say, it was a highly entertaining seance and we would just like to remark in closing that if Lou Mathy and Bart Braznell are really representative of St. Louis citizenry, the considerable village that was founded back yonder by Pierre Laclede must be a pretty nice place in which to live.

PIPELINERS LASH THE GREENSWARD

We hied to Bakersfield on a recent Thursday and attended a meeting of the Western Pipe Liners Club that was held in the celebrated Maison Jaussaud, an attractive night spot, just outside of the Valley oil metropolis. The affair began with a golf tournament or at least something remotely resembling a golf tournament, at the Bakersfield Country Club, and what the boys did to the fairways may be responsible for a somewhat peculiar happening that took place later.

We are told that after the gang left, all the signs reading, "Please replace the turf!" were taken in and a new lot, bearing the legend, "Please returf the place!" were set out. The dinner in the evening was a gastronomic treat, featuring Bakersfield caviar, a delectable concoction, and steaks that were as tender as fresh sunburn. Frank Coyle, Tide Water Associated pipe line chief and president of the Pipe Liners Club, mc'd the dinner in his usual competent and pleasing manner, and was well aided in the process by ex-prexy, Jack Pate, Union Oil Company's southern district superintendent; and current secretary, Charlie House, southern district superintendent for General Petroleum Corporation.

One of the highlights of the dinner was the presentation of golf prizes by Don Frame, the Texas Company's Valley superintendent, who, in this exercise was assisted by a new sleight-of-hand sensation, Johnny White, of Union Oil Company's Valley staff. Johnny made the prizes disappear and reappear with all the aplomb of a Houdini, and if this lad doesn't watch out, he is going to get himself appointed entertainment chairman one of these fine days. About 50 top petroleum people attended the gathering, including a number of well known retired executives, and everyone very obviously had a good time. Next meeting of the Western Pipe Liners Club will be held in Los Angeles in January.

DRILLER IS GOOD GOLFER, NATURALLY!

Gene Reid, a Compton, California, lad, who made good in the contract drilling business has just been signally successful in an altogether different enterprise. According to one of our best undercover men, Fred Hanson, vice president of the California Bank, in charge of oil loans, Gene was recently playing golf on the Stockdale Country Club course at Bakersfield and on the 10th hole, a 125 yarder, his tee shot fell a little short of the green but rolled on up and finally trickled into the cup for a hole in one.

Witnessing this tremedous accomplishment was a trio of reputable petrologists, to wit, Bill Comstock, Bob McCarthy, and Roger Brown. We understand that Gene had been working on this project for 25 years and now that he has learned how to do it will be glad to tip off any other excavator to the *modus operandi*. Golf, incidentally, is rather a precarious pastime for the son of a protestant minister—Gene's dad used to be pastor of the Congregational Church in Maricopa—but from what we hear the golfing contractor never resorts to the fairway-scorching expletives that most of us employ. One of Gene's school chums in Maricopa was Joe Robinson, president of Santa Fe Drilling Company, which reminds us that a few nights ago we bumped into Frank "Pancho" Gess, Leo Goss, and Hal Fullerton, three of the Santa Fe higher-ups, in a local hostelry.

In a short time we were joined by Duke Follansbee, the Universal Consolidated veep, and one of his top engineers, Lee McFarland, whereup the drilling art in all its phases was given quite a going over. Santa Fe Drilling Company is one of the largest contractors in California, with about 16 rigs in foreign service, and another 6 or 8 taking care of domestic requirement.

HERE AND THERE

By way of last minute roundup, Len Price has been elected Big Shot of the Nineteeners for the next year. Ed Pellegrin, the Macco Corporation veep, and Howard Pyle, president of Monterey Oil Company, recently hooked and landed a 227½-lb marlin. It took almost three hours and a lot of pretty sharp navigating by Howard before Ed was able to bring the big fish to gaff. Open house at the Chiksan offices and plant out at Brea was a very pleasant occasion and the diverse operations in the neatly ordered plant departments were most impressive. W. H. Geis well known oil consultant, and Mrs. Geis have just started on an around the world tour that will keep them away from home for a full year.

Meetings

Nov. 5-6—**American Association of Petroleum Geologists,** Pacific Section, annual meeting, Hotel Biltmore, Los Angeles, California.

Nov. 9-11—**Geological Society of America,** annual meeting, Royal York Hotel, Toronto, Ontario, Canada.

Nov. 9-12—**American Petroleum Institute,** annual meeting, Conrad Hilton Hotel and Palmer House, Chicago, Illinois.

Nov. 12-13—**Society of Exploration Geophysicists,** midwestern meeting, Adolphus Hotel, Dallas, Texas.

Nov. 19—**National Industrial Conference Board,** Schenley Hotel, Pittsburgh, Pennsylvania.

Nov. 19-20—**National Association of Corrosion Engineers,** Western region, fall conference, Biltmore Hotel, Los Angeles, California.

Nov. 19-20—**Annual Instrument Short Course,** Los Angeles Harbor Junior College, applied technology division, Wilmington, California.

Nov. 20—**Natural Gasoline Association of America,** Panhandle-Plains Regional meeting, Herring Hotel, Amarillo, Texas.

Nov. 29-Dec. 4—**American Society of Mechanical Engineers,** annual meeting, Statler Hotel, New York, New York.

Nov. 30-Dec. 5—**Exposition of Chemical Industries,** 24th biennial run, Commercial Museum and Convention Hall, Philadelphia, Pennsylvania.

Dec. 1-4—**Corrosion Conference,** University of Oklahoma, Norman, Oklahoma.

Dec. 6-8—**Chemical Specialties Manufacturers Association, Inc.,** annual meeting, Mayflower Hotel, Washington, D. C.

Dec. 7-9—**Oil Industry Information Committee,** Waldorf-Astoria Hotel, New York, New York.

Dec. 13-16—**America Institute of Chemical Engineers,** annual meeting, Hotel Jefferson, St. Louis, Missouri.

Dec. 28-29—**American Chemical Society,** Division of Industrial and Engineering Chemistry, 1953 Symposium, University of Michigan, Ann Arbor, Michigan.

1954

Jan. 11-15—**Society of Automotive Engineers,** annual meeting and engineering display, Sheraton-Cadillac and Statler Hotels, Detroit, Michigan.

Jan. 18-20—**Pipe Line Contractors Association,** annual meeting, Shamrock Hotel, Houston, Texas.

Jan. 18-22—**American Institute of Electrical Engineers,** winter general meeting, Statler Hotel, New York, New York.

Jan. 21-22—**American Industrial Conference Board,** Astor Hotel, New York, New York.

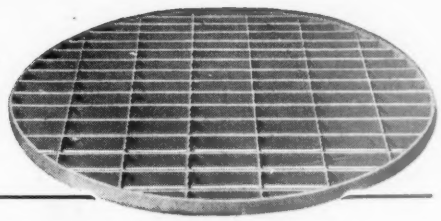
Feb. 15-17—**American Petroleum Institute, Lubrication Committee,** Sheraton-Cadillac Hotel, Detroit, Michigan.

Feb. 26—**Natural Gasoline Association of America,** Permian Basin regional meeting, Lincoln Hotel, Odessa, Texas.

March 1-5—**American Society for Testing Materials,** Spring Meeting, Shoreham Hotel, Washington, D. C.

March 3-5—**American Petroleum Institute,** Southwestern District, Rice Hotel, Houston, Texas.

REMOVE THE DANGER OF OPEN AREAS



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The versatility, economy and steady-going dependability of Wisconsin Air-Cooled Engines in oil field service, on all types of utility units, is today a firmly established tradition. The special suitability of Wisconsin Engines for this kind of service has been conclusively proved not only by performance records of many leading oil producers and pipe line operators, but also through continuous field testing.

Any job that can be handled within a 3 to 36 hp. range, can be handled to maximum advantage with Wisconsin Heavy-Duty Air-Cooled Engine Power.

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Big-Blade Yardage

Baker 9X Dozer . . . shown building fire walls around oil tanks . . . demonstrates big-blade yardage.

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SPECIFICATIONS

9X: Blade 46" high, only 96" wide.* Drawbar hp—72.
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*Both the 9X and 15X can be hauled anywhere—day or night—without special highway permits.

Throughout the petroleum industry the revolutionary Baker 9X Dozer is accepted as a time and money saver!

Why? Because the 9X is the only proven big bulldozer which offers both tractor and dozer frame built into one integral unit.

What Does This Mean to You? It means you can now get a big capacity bulldozer in a compact package—designed to gain full advantage of weight and gravity. The result is maximum down-pressure—peak yardage under all conditions—and fast, flexible action. The 9X bites deep—down to 13" below ground level—and lifts high, up to 37". And the weight distribution is right . . . no need to remove the blade when pulling heavy loads.

Get the Facts—NOW—ask for Bulletin 896-A. The Baker Manufacturing Company, Springfield, Illinois.

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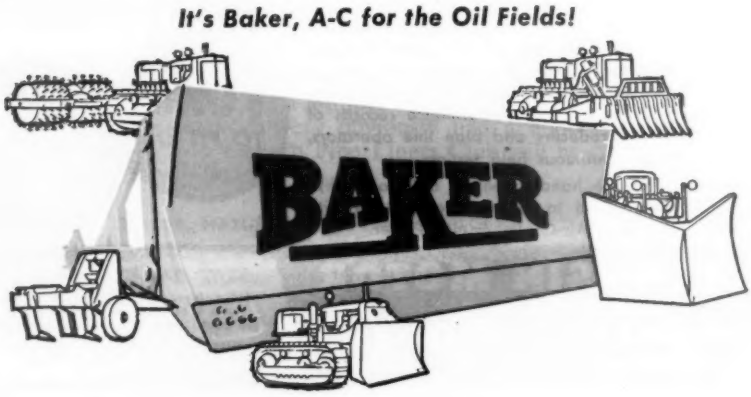


June 17-19—**American Petroleum Institute,** Division of Production, Eastern district, Greenbrier Hotel, White Sulphur Springs, West Virginia.

March 4-5—**American Gas Association, Transmission and Storage Conference,** Jung Hotel, New Orleans, Louisiana.

March 8-10—**American Institute of Chemical Engineers,** Statler Hotel, Washington, D. C.

March 15-19—**National Association of Corrosion Engineers,** annual meeting, Kansas City Municipal Auditorium, Kansas City, Missouri.

March 17-19—**American Petroleum Institute,** Division of Production, Mid-Continent District, Skirvin Hotel, Oklahoma City, Okla.

March 25—**National Industrial Conference Board,** Ambassador Hotel, Los Angeles, California.

March 25-26—**New England Gas Association,** Statler Hotel, Boston, Massachusetts.

April 8-9—**American Petroleum Institute,** Division of Production, Rocky Mountain District, Townsend, Gladstone and Henning Hotels, Casper, Wyoming.

April 12-15—**Society of Automotive Engineers,** national aeronautics meeting, Statler Hotel, New York, New York.

April 21-23—**Natural Gasoline Association of America,** annual convention, Baker Hotel, Dallas, Texas.

May 2-4—**Independent Petroleum Association of America,** midyear meeting, Cosmopolitan Hotel, Denver, Colorado.

May 3-5—**American Petroleum Institute,** Lubrication Committee, Skytop Lodge, Skytop, Pennsylvania.

May 3-5—**American Geophysical Union,** annual meeting, National Academy of Science, Washington, D. C.

May 6-7—**American Petroleum Institute,** Pacific Coast District, Division of Production, Statler Hotel, Los Angeles, California.

May 9-12—**Liquefied Petroleum Gas Association,** annual convention, Conrad Hilton Hotel, Chicago, Illinois.

May 10-12—**American Petroleum Institute,** Division of Transportation, Producti Pipe Line Conference, Warwick Hotel, Philadelphia, Pennsylvania.

May 10-13—**American Petroleum Institute,** Division of Refining, midyear meeting, Rice Hotel, Houston, Texas.

May 16-19—**American Institute of Chemical Engineers,** Conrad Hilton Hotel, Chicago, Illinois.

May 20-21—**National Industrial Conference Board,** 38th annual meeting, Waldorf-Astoria Hotel, New York, New York.

May 31-June 5—**American Petroleum Institute, Division of Production,** midyear committee conference, St. Francis Hotel, San Francisco, California.

NOMADS TO MEET

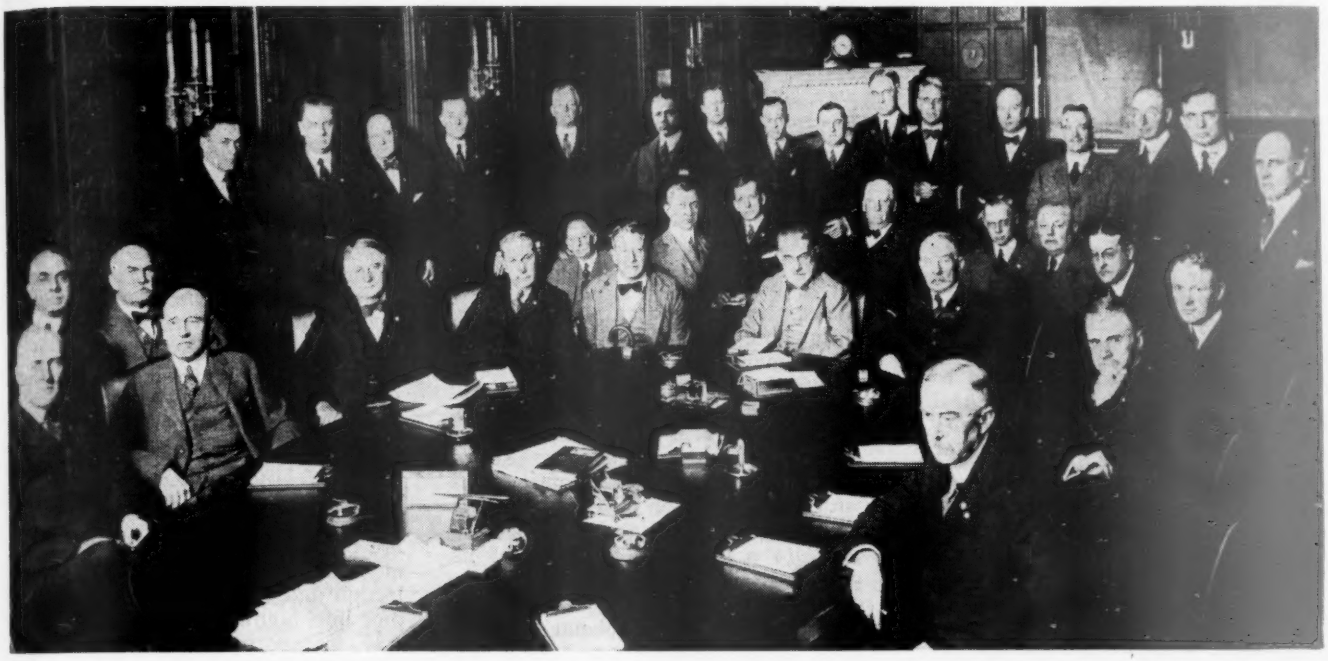
New York, N. Y., Chapter, First Monday of the Month, Biltmore Hotel, New York. Secretary, O. B. Latrobe.

Houston Chapter, Second Monday of the Month, Ye Olde College Inn, Houston, Texas. Secretary, Harry E. Estes.

Los Angeles Chapter, Second Wednesday of the Month, Jonathan Club, Los Angeles, Calif. Executive Secretary, Wallace A. Sawdon.

Tulsa Chapter, Third Friday, "After Five" Room, Hotel Tulsa. Secretary, Gilbert Swift.

Dallas-Fort Worth Chapter, Dallas, Texas. First Monday of the Month. Secretary, M. W. Hiltpold.



FIRST API BOARD OF DIRECTORS. First row, seated: **A. C. Bedford,** chairman of the National Petroleum War Service Committee, and chairman, board of directors, Standard of New Jersey; **M. L. Requa,** director, Oil Division, U. S. Fuel Administration; **J. W. Van Dyke,** president, Atlantic Refining; **George S. Davison,** president, Gulf Refining; **T. A. O'Donnell**, director of production, Oil Division, U. S. Fuel Administration; **H. L. Doherty,** president, Cities Service; **E. W. Clark,** president, Union Oil of California; **H. E. Felton,** president, Union Tank Line; and **R. D. Benson,** president, Tide Water Oil Company.

Second row, seated: E. C. Lufkin, president, The Texas Company; **Martin Carey,** general counsel, Standard Oil of New York; **Edward Prizer,** president, Vacuum Oil; **Ivy Lee,** director of publicity for National Petroleum War Service Committee during World War I; **Samuel Messer,** president, Emlenton Refining; **J. C. Donnell,** president, Ohio Oil; **A. G. Maguire,** U. S. Fuel Administration; **W. P. Cowan,** former president, Standard (Indiana); **H. M. Blackmer,** president, Midwest Refining; **J. S. Cosden,** president, Cosden and Company.

Third row, standing: W. C. Teagle, president, Standard of New Jersey; **J. E. O'Neil, president,** Prairie Oil and Gas; **H. F. Sinclair,** president, Sinclair Oil and Refining; **J. H. Markam, Jr.,** Tulsa, Oklahoma, producer; **George W. Crawford,** president; Ohio Fuel Supply; **J. Howard Pew,** president, Sun Oil; **C. C. Smith,** assistant secretary and treasurer of petroleum commitee for W.W.I.; **J. A. Moffett,** secretary of the committee; **J. F. Guffey,** president, Natural Gas Association of America; **J. H. Barr,** president, National Supply; **Frank Haskell,** president, Mid-Continent Oil and Gas Association; **W. S. Farish,** president, Gulf Coast Oil Association; **M. J. Byrne,** president, Independent Oil Men's Association; **J. A. Middleton,** U. S. Fuel Administration; **R. L. Welch,** secretary and general counsel, Western Petroleum Refiners Association; and **A. P. Coombe,** president, Standard Oil of Ohio. These members of World War I oil committee became API directors.

API Is Oil Industry's University

This central agency includes all branches, directs research and information services, provides a means of exchanging ideas in discussion groups, develops high efficient standards for equipment

IN a broad sense, the American Petroleum Institute is like a large university —a great educational center and clearing house for petroleum history and petroleum progress.

Thousands upon thousands of oil men have contributed to its success. Their goal is and has been a common one — the advancement of the arts and sciences of the industry specifically, and the betterment of mankind generally.

EXCLUSIVE

Aside from administrative functions, the Institute work is done largely by volunteers. The results that have been achieved are striking examples of what can be accomplished cooperatively in an industry known for the intensity of the rivalry among its competitive units.

The Institute is comprised of working committees, literally hundreds of them. Their reports and studies represent the pooled thinking and the best knowledge in the industry. Their achievements have reached such a magnitude that they are immeasurable in terms of money or in that incalculable factor, human life itself. This committee work is conducted on so large a scale at the present that in 1952

alone more than 150,000 oil men attended API-sponsored meetings, sharing or participating in discussions about industry-wide problems. At the 32nd annual meeting in Chicago last November, more than 160 separate meetings, the bulk of them on the committee level, were held over a period of several days.

Recognized at home and abroad for its integrity and the scope of its work, the API has compiled a proud service record, which, among other things, provides:

1. A unified organization to cooperate with federal and state governments, and to present oil industry facts and statements when invited to do so;

2. Representative panels to work with non-governmental agencies and with other industries to study and seek the solution of common problems;

3. Open forums for the discussion of intra-industry technical and engineering problems and for the development of recommended standards for certain types of equipment, materials and good practice in their care and use;

4. A central agency, open to all, for the collection of facts about the oil industry, and a repository of authoritative information about it.

The Institute, by edict and policy, does not concern itself with controversial or comeptitive matters. Its studies and work are limited to those things that are for the common good of the industry, and on which there is common agreement. It does not, for example, study or discuss prices in any way, shape or form, as these are regulated entirely by competition, and the laws of supply and demand. It will not enter any area which might have any effect on normal competitive forces. API does not "represent' nor serve as a spokesman for the oil industry.

But it is representative of the entire oil industry operating in the United States. Its membership is scattered throughout the country. Some are big, some small, some are old, some new. They are engaged in almost every enterprise having to do with petroleum. At the last annual meeting in Chicago, more than 6400 persons registered and attended sessions. Comparing this with the registration of 420 at the first annual meeting in Washington in 1920 provides a graphic illustration of its growth in little more than three decades.

The American Petroleum Institute came into existence on March 20, 1919. An outgrowth of the National Petroleum War Service Committee of World War I, it was established to continue in peacetime as much of its wartime cooperation as could be conducted within the framework of the law.

The objectives were set forth in simple terms in its charter. They are:

1. To afford a means of cooperation with the government in all matters of national concern.

2. To foster foreign and domestic trade in American petroleum industry in all its branches;

3. To promote, in general, the interests of the petroleum industry in all its branches;

4. To promote the mutual improvement of its members, and the study of the arts and sciences connected with the petroleum industry.

So many and varied are the Institute's activities that it is impossible with brevity to enumerate or describe them. They enter the fields of equipment standardization, design, care, and good practice in its use; fundamental and applied research; accident and fire prevention; waste disposal; testing methods; prevention of corrosion; collection and dissemination of statistics; pipe line, highway, waterway, and railway transportation; public information; education; economics; metallurgy; accounting; nomenclature; engineering; agriculture, and taxation.

Major activities are indicated by the names of the four divisions, viz., Division of Production, Division of Refining, Division of Marketing and Division of Transportation; by the Departments of Information; the American Petroleum Industries Committee — the tax arm of the organization; the Department of Technical Services, which embraces safety and fire protection, engineering, agriculture, and medical advisory services; the Department of Statistics; and by functional committees of the board of directors such as Awards, Defense Services, Financial and Accounting, Highways, National Oil Policy, Public Relations, Fundamental Research, Crude Oil Reserves and Safety. One of the API's largest and most far-reaching activities is the Oil Industry Information Committee — the public relations program.

The achievements of the API are many over its 34 years of history. Probably the most outstanding is the vast committee structure of the API itself, and the regional, divisional, and annual meetings. Through these, the working knowledge of many oil companies, much of which would be jealously-guarded secrets in most industries, is shared regularly with the entire industry, interested government agencies and the public generally.

These discussions, and the ever-higher standards established by the committees, have saved the industry and the public probably many millions of dollars. Unquestionably, they have hastened by years the adoption of many new techniques which have made possible the rapid advances of the industry in the last 30 years.

Particularly outstanding too are the

API Convention, 1953

Broad Coverage of Drilling and Production Methods

API's culmination of its yearly efforts to forward the cause of the industry, will be an outstanding 33rd annual convention.

Opening with registration and committee meetings on Sunday afternoon, November 8, the program is scheduled almost around the clock through the closing session of the joint meeting to be held the following Friday morning when the Central Committees on Accident Prevention and Fire Protection will hold the floor. Attendance is expected to exceed 6500 members of the oil fraternity and to push the total attendance at annual meetings held since its inception in 1920 to over 90,000.

In the Division of Production, Monday's session on Fundamental Research will feature addresses by Robert E. Wilson of Standard of Indiana, chairman of the Research Committee, and T. W. Nelson of Socony-Vacuum, chairman of the Advisory Committee. Reports on the fundamentals of hydrocarbon behavior, the mechanism of the displacement of oil from porous materials, and a study of near-shore recent sediments and their environments in the Northern Gulf of Mexico will be given. Committee meetings are also scheduled all day Monday with a dinner meeting of the central committee on drilling and production practices planned.

Tuesday morning will also be devoted to various committee meetings. Of special interest in the Division of Production will be the afternoon session where C. L. Orn, Ohio Oil, reports on operations in the tidelands and Lon Putman, Gulf, on operations on federal lands in the Rocky Mountains.

At the general session Wednesday morning, Pure Oil Company's L. S. Wescoat, chairman of the API's board of directors will preside. Remarks of the API president, Frank Porter will precede addresses by John J. McCloy, chairman of the board of the Chase National Bank of New York, and Governor Johnston Murray of Oklahoma.

Drilling Research Inc., will report investigations of rock failure in percussion at the Wednesday group session.

At the final general session Thursday morning, three addresses are planned by P. C. Spencer, president of Sinclair Oil Corporation, Lewis W. Douglas, chairman of the board, The Mutual Life Insurance Company, and Douglas McKay, Secretary of Defense, Petroleum Administration for Defense.

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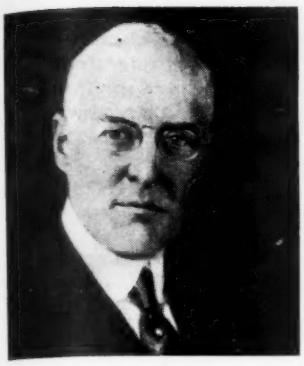
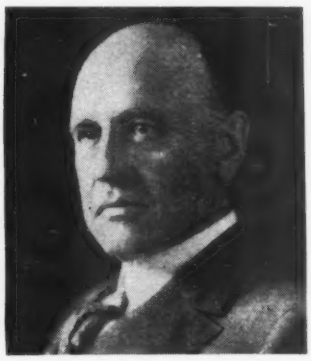




TWO ORGANIZERS. A. C. Bedford, chairman of the board, Standard Jersey, and Mark L. Requa, head of Oil Division, U. S. Fuel Administration during World War I, helped push through the formation of API. Bedford has been called the "Father of API." Both served on World War I petroleum committee.

TWO API PRESIDENTS. Thomas A. O'Donnell, director of production, Oil Division, U. S. Fuel Administration, was elected president in 1919 when API was organized. He was elected five times in the first five years. **Frank M. Porter,** president of Fain-Porter Drilling Company, took office in 1950.

recommended standardization programs which took the chaos out of the production and refining fields, both in equipment and its physical operations. In the same category are the recommended safety and fire protection practices which have minimized the danger element in industry operations and in the handling of flammable gasoline, oils and other volatile fluids.

Still, other important operations are its statistical reports on industry operations, which are available long before government statements, and its informational services, which answer thousands of inquiries yearly, and cover the publication of many pamphlets and booklets about oil history and progress as well as factual and technical books.

Under API sponsorship, the industry has worked out recommendations for a uniform system of accounting practices. The annual report of the API's reserves committee gives the nation a concrete estimate of its proved reserves of crude oil still buried in the earth. Still other highlights of API activities are its vocational training program, a $700,000 a year fundamental research program and numerous special studies.

Headquarters of the API have been in New York City since its founding. Currently the main offices are in the Radio City section of Manhattan. Regional offices are maintained in Washington and Dallas, Texas. A statistical collection and service staff is maintained in Los Angeles, California.

Chief among the individuals active in the formation of the Institute were A. C. Bedford, chairman of the board of Standard Oil Company (New Jersey), who, in retrospect, has been called the "Father of the API;" Mark L. Requa, wartime head of the Oil Division of the U. S. Fuel Administration; Thomas A. O'Donnell, director of the government's Production Division, and Robert L. Welch, secretary of the Western Petroleum Refiners Association.

All were members of the National Petroleum War Service Committee which functioned so well in World War I, with Bedford as chairman. With the incorporation of the Institute in 1919, the entire membership of the NPWSC became the API's first board of directors. The first board numbered 40 persons; today, there are 129 on it.

O'Donnell, who was president of the California Petroleum Corporation, was elected first president of the Institute. Welch, a former Iowa lawyer who had been counsel for the independent jobbers in that state, was named the staff and administrative head, with the title of "General Secretary and General Counsel."

O'Donnell was elected five times during the first five years of API existence. Other API presidents, and their tenure in office, were: J. Edgar Pew, vice president of Sun Oil Company, from December 11, 1924 to January 21, 1926; William S. Farish, president of Humble Oil and Refining Company, January 21, 1926 to December 9, 1926; E. W. Clark, vice president of Union Oil Company of California, December 9, 1926 to December 5, 1928; Edwin B. Reeser, president of Barnsdall Oil Company, December 5, 1928 to November 11, 1931; Amos L. Beaty, former president of The Texas Company, November 11, 1931 to November 16, 1932; Judge C. B. Ames, general counsel and later chairman of the board of The Texas Company, November 16, 1932 to May 17, 1933; Axtell J. Byles, former president of Tidewater Associated Oil Company, May 17, 1933 to September 28, 1941; William R. Boyd, Jr., September 28, 1941 to November 9, 1949; Baird H. Markham, chairman of the American Petroleum Industries Committee, served as acting president for the period of November 9, 1949 to May 1, 1950, when Frank M. Porter, president of Fain-Porter Drilling Company, and former president of Mid-Continent Oil and Gas Association, took office. Porter is still president.

The accomplishments of the Institute in the standardization of oil field equipment is probably its greatest single achievement.

In the old days, threaded connections on accessory equipment in the drill stem, in joints, collars and bits, rarely fitted together, if they came

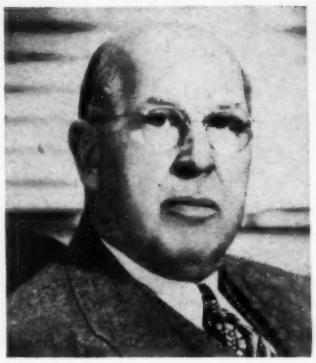
API Convention, 1953

API Refining Sessions at National Convention

John W. Newton, API vice president for refining, will preside at the refining group session Monday afternoon, November 9. Newton is vice president of Magnolia Petroleum Company. The session will hear a paper on "Fluid Coking of Residue" by A. Voorhies, Jr., Esso-Standard Oil Company, and H. V. Martin, Standard Oil Development Company. A second paper on "Lummus Continuous Contact Coking Process," will be given by Valentine Mekler. A. H. Schuette, and T. T. Whipple, all of Lummus Corporation.

Meetings of the Division of Refining will begin at 9 a.m. Thursday, November 5, at the Conrad Hilton when the subcommittee on corrosion will meet with E. Q. Kemp as chairman. One meeting at 9 a.m. Saturday, November 17, will cover low pressure storage tanks and another will be held on refinery valves. Safety and relief valves will be the subject of the afternoon session.

The Sunday program includes Petroleum Products, Mechanical Equipment and Centrifugal Pumps, at 9 a.m. At 2 p.m. Automobile Research, Refining Inspection Supervisors, and Valves will be discussed in committee. Monday meetings will cover unfired pressure vessels, the program committee, instruments, and electrical equipment, nominating committee report, advisory committee report, smoke and fumes technical advisory committee report. Tuesday morning at 9 a.m. two committees will hold meetings, one on refinery equipment and the other on smoke and fumes.



STANDARDIZATION. Carl A. Young, right, became director of the API Division in 1924 and launched a campaign to make equipment to standard specifications. In 1928 W. G. Skelly of Skelly Oil Company backed up the standardization program and called for greater effort to make equipment parts useful in more places.

from different manufacturers. And there were times, too, that they didn't fit, even if they did come from the same manufacturer.

Things are different now. To be sure, drilling for oil still has its share of heartbreaks and headaches. But standardization has taken the sting out of many of the modern problems.

So much so, in fact, that a driller can sit in the deepest, darkest part of Africa, order component parts of a drilling rig from manufacturers located in 15 different countries, and know that the parts will mesh perfectly, when they arrive at his jungle headquarters.

Industry leaders have remarked time and again that if API had accomplished nothing else in its three decades of history than its production standards and specifications, it had more than justified its existence as a trade association.

The record shows that standardization came in for its share of discussion at the very first meeting of the Institute in 1920. In 1923, the API Board of Directors authorized the appointment of several committees to work out an approach aimed at solving the problem.

In May 1924, the Institute hired a young man who had been an executive with an equipment manufacturer. He was appointed director of the Division of Standardization, which was later to become the API Division of Production. This was Carl A. Young, who retired last July 1 as director of the Division of Production.

In 1925 the Central Committee on Standardization of Oil Field Equipment was organized to govern all activities of the program. The late J. Edgar Pew, then vice president of Sun Oil Company, was the first chairman. He served until 1946 when he was succeeded by John R. Suman, vice president of Standard Oil Company (New Jersey).

The Institute directed that its work would be concerned with the preparation and publication of specifications and recommended practices on all major items of equipment used in oil production. The general objectives were: (1) simplification of sizes, grades and designs; (2) standardization of dimensions which affect interchangeability (3) stabilization and improvement of quality; and (4) development of economical practices for care and use of equipment.

It is difficult to calculate the savings to the industry of the standardization program that resulted. It has been estimated, however, that it effects a savings of more than $50,000,000 each year. It is of interest to note that the value of products made annually to API standards is on the order of a half billion dollars, not taking into account materials manufactured and distributed abroad.

Every year, standardized equipment saves countless men hours of labor in drilling operations. This efficiency makes itself felt by both speeding up and increasing production of crude oil. Standardization, then, has through the years exerted a direct and an important influence on the capabilities of the industry to find and produce ever-increasing supplies of oil. The government has acknowledged the value of API specifications. It made them mandatory during the critical years of World War II when oil was fueling the Allies on the road to victory.

In 1928 when the standardization program had been in operation for only five years, W. G. Skelly of the Skelly Oil Company spotlighted its contributions and urged its widespread acceptance in an address delivered before the API ninth annual meeting.

"Proper standardization will result in reducing our investments in inventory of materials, both to the operators and the manufacturers," Skelly said. "One operator reported that he had over 50,000 different kinds of material in his warehouses due to the variety of sizes and brands in general use."

Skelly cited the following typical reductions in inventory, made possible through API standardization in its first five years:

Cable Drilling Tool Joints: Before standardization, 306; reduced to 11 API sizes.

Derricks: Before standardization, over 200 different sizes; reduced to 11 API sizes.

Rotary Drilling Taper Joints: Before standardization, over 200 different sizes; reduced to seven API sizes.

"What does all this mean to us as executives?" Skelly asked. "It means that instead of installing and paying for large departments in our own organizations to prepare our own specifications, we can secure them through the Institute at a very nominal sum. It means that we will receive an article under a better specification than any single company could prepare because it would be practically impossible for any single company to find in its own organization the wide practical experience and technical advice necessary to properly prepare a national specification. On the question of master gages alone, which is the fundamental cornerstone of any progressive standardi-

API Convention, 1953

Transportation Division Has Comprehensive Program

Pipeliners will find the Division of Transportation's part of the 33rd API meeting sufficiently diversified to satisfy every taste. Included among the technical papers to be presented at the all-day symposium on Tuesday, November 10, are discussions of pipe line transportation of propane, electronic "brains" to solve pipe line problems, corrosion control technique developments, advances in pipe line construction techniques, the future of lease tankage, and formulas to aid in selecting the proper pipe diameter for minimum investment.

The story of the "Big Inch-by-Inch" and how it was laid across the rugged Canadian Rockies will be revealed in a full-length color movie by H. H. Anderson of Trans Mountain Pipe Line Company, as an added Tuesday attraction.

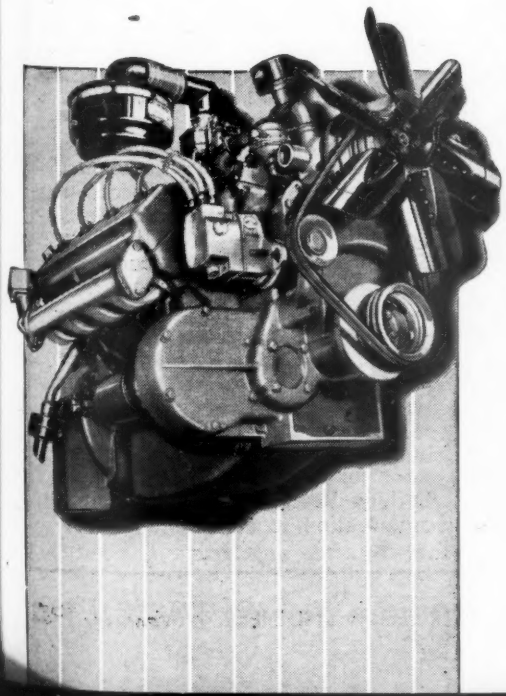
For the opening session, with P. C. Spencer presiding, features will include an address by Robert B. Murray, Jr., Under Secretary of Commerce for Transportation, and an address by W. L. Davidson, director of the office of Industrial Development, Atomic Energy Commission. "Operations Greenhouse," a documentary color movie on proof-testing of atomic weapons, will highlight the program.

Spencer, vice president for transportation of the API, will present the annual API certificates of appreciation to outstanding transportation men. Another feature address will be given by A. A. Stambaugh of Standard Oil of Ohio.

Committee meetings will get a head start on the major program, with the first committee group assembling Saturday, November 7, and the discussions will continue Wednesday afternoon. Numerous joint meetings involving up to 10 different interest groups will be held on Monday. Major committee discussion topics of interest to pipeliners include construction practices, lease-tank practices, field welding, corrosion, engineering law and regulation, pipe-line technology.

Photo courtesy Hale Fire Pump Company, Conshohocken, Pa.

Chrysler Power provides modern solution to age-old problem of irrigation



Early last summer, the owner of this 640-acre farm near Williamsburg, Virginia, decided to irrigate 120 acres. Taking his water from the nearby James River, he irrigated 70 acres of corn, 50 acres of soy beans. Water was pumped at the rate of 960 gallons per minute, fourteen hours a day, seven days a week. Each acre required approximately 36,000 gallons.

The results were astounding. Not only did this farmer save his crops during an especially dry summer, but his corn and soy bean yields actually *increased* 100% over the year before. In each case, 1952 was considered a normal year.

What this farmer did with his Hale Model CIRV Pump demonstrates again the effectiveness of Chrysler Power. Here the 331-cubic-inch displacement Model 20 V-8 Engine is used because the manufacturer wants great power with light weight, continuous, economical operation.

Manufacturers find Chrysler Engines ideal for almost any equipment requiring extra power without extra weight. Manufacturers also find they can order engines equipped *by Chrysler* to meet the needs of the equipment and their customers. For example, Chrysler Engines can be supplied with gasoline, natural or liquid propane gas burning carburetors, standard or gear-driven front ends, 12 or 24 volt electrical system.

Chrysler Industrial Engines are not expensive. Production line methods, adapted to specialized industrial engine building, provide a custom-built engine at mass-production prices. See a Chrysler Industrial Engine Dealer, or write:

Dept. 1711, Industrial Engine Division, Chrysler Corporation, Trenton, Michigan.

CHRYSLER
Industrial Engines

HORSEPOWER WITH A PEDIGREE

ONLY TWO MEN known to have attended every API meeting since the beginning of the trade association are J. S. "Doc" Cooke, secretary of the Oil Industry Information Committee, and secretary of the Public Relations Committee of the API Board of Directors, and William S. Boyd, Jr., former president of API. Cooke has been with the Institute since 1920. Boyd also joined the API in 1920, and retired as president in November, 1949.

zation program, an important official of the Bureau of Standards stated that the Institute has accomplished more in the last two years than any other industry has done in twenty.

"Another important accomplishment deserving of mention," he continued, "are the codes on the proper care and use of equipment issued by the standardization committees. They were not content to formulate specifications alone, but have prepared minute instructions on correct methods for the care and use of materials in the field, to the end that the greatest possible value can be secured from our material purchases. The Institute has also prepared posters giving condensed rules on the proper care and use of equipment, which should be posted in every field office, warehouse or bunkhouse where the men usually congregate. We could do no greater service to ourselves than to put a copy of these codes and posters in the hands of every foreman, driller and tool dresser in the field. We owe it to the small operator, who usually follows the practice of the larger operator, and who lacks all of these technical and practical facilities, to make them available to him by endorsing, through actual usage, these API standards."

Today there are 487 manufacturers in the United States and 133 manufacturers outside this country who have been licensed to stamp the API monogram on their drilling equipment. The monogram appearing on a product means that it measures up to the rigid API specifications.

In the United States, the state of California leads with 117 licensees. The first five states include Pennsylvania, 63; Texas, 61; Ohio, 47; and Oklahoma, 37.

On a world-wide basis, England has 39 licensed manufacturers; Germany, 28; Canada, 26; France, 12; Italy, 11; Japan, 4; Austria, 2; Belgium, 2; Holland, 2; Scotland, 2; Australia, 2; Sweden, 1; Switzerland, 1; and Dutch East Indies, 1.

Not long ago there was striking evidence of the value of the API program. During a steel shortage in this country, several thousand tons of tubular goods were imported from England, Germany, Belgium and France. The foreign pipe interchanged perfectly with the American product. No time was lost in maintaining drilling and production activities.

In this connection, the Central Committee on Standardization includes 11 major topical committees, each of which is responsible for specifications and recommended practices in its field. Items covered range in size from ¾-in. sucker rods and 1¾-in. working barrel cups up to steel tanks for oil storage of around 300,000 bbl capacity.

Fields covered by specifications and recommended practices include: Belting, boilers, cable drilling equipment, derricks and masts, tubular goods, valves and fittings, rotary drilling equipment, wire rope, oil well cement, production equipment and tanks for oil storage.

The extraordinary success of API standards and specifications and the boundless benefits they provide to the oil industry are a monument to the resolution and ability of far-sighted oil men, who made them possible and to the countless thousands who worked out the details through the years. * *

API Convention 1953

API Oil Men Get Certificates

Certificates of appreciation will be presented to 31 oil men in recognition of outstanding service to the industry and the American Petroleum Institute at the Institute's 33rd annual meeting in Chicago, November 9-12, in the Conrad Hilton hotel and the Palmer House.

Recipients are Stuart E. Buckley, Humble; Ben B. Cox, Gulf; L. M. Henderson, Pure Oil; Wayne E. Kuhn, Texas; William Finnegan, Jr., Humble; W. Chalmers Burns, Hartol; Emmett Howard, American Oil; W. J. Loufman, Fleet Wing; Frank V. Martinek, Standard Indiana; A. T. Smith, Continental Oil; L. E. Hanson, Socony-Vacuum; Henry Schwall, Shell; A. G. Anderson, Socony-Vacuum; T. E. Buchanan, Texas; Charles Fitzgerald, Sinclair; B. B. Howard, Standard New Jersey; Gavin W. Laurie, Atlantic; J. P. Patterson, Pan American; H. A. Rhodes, Transcontinental; L. S. Wrightsman, Humble Pipe Line.

J. C. Donnell, II, Ohio Oil; L. R. Smith (deceased), Tide Water Associated; B. R. Carney, Warren Petroleum; C. W. Alcorn, Falcon-Seaboard Drilling; George P. Bunn, Phillips; Frank E. Eckert, Hanley and Bird; J. G. Montgomery, Jr., United States Natural Gas; J. H. Newlon; J. French Robinson, Consolidated Natural Gas; Chase E. Sutton, Pure, and Cyrus S. Gentry, Wolverine Pipe Line.

Some Papers Scheduled for Chicago Meeting

- "Myth of Monopoly" will be given by H. S. M. Burns, president of Shell, at Public Relations session Monday morning, November 9, 1953.
- "Oil and the Atom" will be presented by Dr. W. L. Davidson, director, Office of Industrial Development, Atomic Energy Commission, at Transportation session Monday afternoon.
- "Danger of Default," by Dr. Charles Allen Thomas, president, Monsanto Chemical Company, at Marketing session, Monday afternoon.
- "Umpires in Management," by Reese H. Taylor, president Union of California, at Financial and Accounting session Tuesday morning, November 10, 1953.
- "Twin Keys to Successful Management," by Donald P. Jones, Sun Oil, at same session.
- "Acquiring Properties Through Oil Payments and Related Methods," by G. W. Welsch, of Lybrand, Ross Brothers, and Montgomery, at Financial and Accounting session Tuesday afternoon.
- "Economic Change and Business Plans," by Richard H. Heflebower, chairman, department of economics, Northwestern University, same session.
- "Recent Advances in Pipe Line Construction," by C. C. Bledsoe, Midwestern Constructors, Inc., at Pipe Line symposium, Tuesday afternoon.
- "Operations on Federal Lands in the Rocky Mountains," by Lon J. Putnam, Gulf, at Production session Tuesday afternoon.
- "What Should an Engineer Expect From a University Education?" by Dr. William V. Houston, president, Rice Institute, at same session.
- "Top Management View of Supervisory and Management Development," by O. A. Ohmann, Standard of Ohio, Production session, Wednesday afternoon, November 11.
- "Perspective on the World Oil Picture," by John R. Suman, vice president, Standard Jersey, at same session.
- "Some Results of DRI Investigations — Rock Failure in Percussion," by Dr. John V. Pennington, Drilling Research, Inc., (non-profit organization) at same session.

XUM

Organization of technical societies must be given substantial credit for the rapid advance of the petroleum industry — there are many

Professional Groups in Western Canada

FLOYD K. BEACH

THE name of the publication that carries this story is in itself a challenge to tell its readers something of the progress of petroleum engineers in our part of the world. Before launching into the subject too deeply, let us remark that in the registration of professional engineers in Alberta and other Canadian provinces, geologists are considered engineers and there is no separate registration for them nor for geophysicists or other technical specialists. The law segregates them from medical, dental, legal, and chiropractic personnel, but the geologists, etc., who practice in kindred subdivisions of the petroleum and natural gas industry and represent themselves as technical persons are all "engineers" according to law. Hence we exercise a little license in discussing activities of these kindred skills.

The Author

Floyd K. Beach has been connected with the oil and gas industry in Alberta for 25 years. He is practicing as a consultant and is Western field editor for *Canadian Oil and Gas Industries*, published in Gardenvale, Quebec. He is a member of the Engineering Institute of Canada, Professional Engineers of Alberta, Canada Institute of Mining and Metallurgy, American Association of Petroleum Geology, Alberta Society of Petroleum Geologists. He was graduated from Traverse City high school and attended Albion College.

Geologists

Back more than 25 years ago a small group of geologists in Alberta began discussing the formation of a geological society and this developed into the Alberta Society of Petroleum Geologists. Its first roll of membership included perhaps a dozen men. At the 1953 annual meeting held January 21, seven of the original members were present and were given life memberships, and another four sent letters of regret.

Dr. John A. Allan, Professor Emeritus of geology at the University of Alberta, reminded the gathering that when the society was formed, geologists were expected to talk of everything else but geology when they got together. Secrecy was the keynote in oil prospecting even if it meant that several geologists might do surface studies of the same area without disclosing their observations of what was apparent to all who wished to look. That policy was not one originating with the geologists but with their employers who failed to appreciate anything other than the fact that they had paid out good money for services rendered and saw no reason for letting competitors benefit from their expenditures, and perhaps jump in to lease up some spot they considered favorable. The speaker credited the society with breaking down the barriers of secrecy and at the same time advancing the possibility of all concerned finding more oil through exchange of scientific data. At first only stratigraphic information was considered suitable to discuss and until matters had progressed further, geologists avoided discussing structure. Later developments have modified even exchange of information on structure.

Today the Alberta Society of Petroleum Geologists has a paid membership of around 500, and a similar society has grown up in Saskatchewan. The Alberta Society began publication of a monthly news letter this year. Its coverage includes summaries of papers presented, personals and contributions that have not been presented at meetings. A luncheon meeting is held monthly and evening meetings are called as occasion demands.

The Society has been favored by distinguished lectures sponsored by the American Association of Petroleum Geologists and the broader outlook induced by visiting geologists from the United States has helped to put local problems into their proper perspective. Some very worthy papers have been presented by members of the Alberta Society. Early papers were collected and published in the Bulletin of the AAPG of October, 1931 and reprinted as "Stratigraphy of Plains of Southern Alberta, Donaldson Bogart Dowling Memorial Symposium." For many years this volume became reference work for young geologists. Recently AAPG has gathered subsequent papers in a volume under editorship of L. M. Clark and it is now available.

For several years the Alberta Society has held an annual field trip. The 1953 event covered three days, the first day consisting of a meeting in Calgary where abstracts of papers appearing in the guide book were presented, and two days in the field. Geologists from all over the continent gathered and 320 persons in about 100 cars covered a tour from Calgary through Turner Valley oil field and south to Crowsnest Pass, returning by a more westerly road. Frequent stops with public address facilities enabled the gathering to see the geological exposures through the eyes of those who had made special studies of the terrain.

The guide book is a truly professional effort, containing numerous papers as well as the actual guide to the route taken. The Society has gambled on a wider distribution than to actual participants in the trip and copies of the book can be obtained from Barney Clare, 300 Ninth Avenue West, Calgary, $5.50. The 230 pages make a reference volume invaluable to those working in Alberta.

History of Oilfield Technology Society

Another active organization is Oilfield Technical Society. Its history is not so old as that of the geologists and its functions relate to engineering problems in prospecting and field development, special services available, reservoir engineering and related matters.

OTS has an outlet for publication of papers presented in *Canadian Oil and Gas Industries*, published monthly at Gardenvale, Quebec, and the writer of this story is Western field editor. Meetings are held monthly in Calgary, and Edmonton also holds meetings. The dinners with preliminary cocktails afford opportunity for members to get personal contacts over and above the more formal papers.

Papers presented have included such subjects as new methods of logging wells, mud engineering, cementing, completion methods in various fields, reservoir characteristics of various fields. Some papers have appeared on the first view as advertising the wares of various service companies, but in retrospect they have all been most

EXCLUSIVE

AT THE DIAMOND "M"-
SHARON RIDGE GASOLINE PLANT
SCURRY COUNTY, TEXAS
16,080 Cooper-Bessemer Horsepower

• As shown opposite, modern Cooper-Bessemers team up to meet over-all power requirements at the Diamond "M" - Sharon Ridge Gasoline Plant, Scurry County, Texas. This plant now has twelve 1100 HP GMV's, each equipped with three compressor cylinders for 3-stage compression to 525 psi.

The companies participating in the Diamond "M" have had broad experience with GMV qualities — in other gasoline plants, in major chemical plants and *wherever* large scale compressing demands continuous, low-cost performance. That's one reason — experience — why GMV's were picked for this jointly owned operation.

. If your plans call for compressor service, power generation or both, check with the nearest Cooper-Bessemer office on modern units that will keep your costs at a minimum.

FOR PROCESS

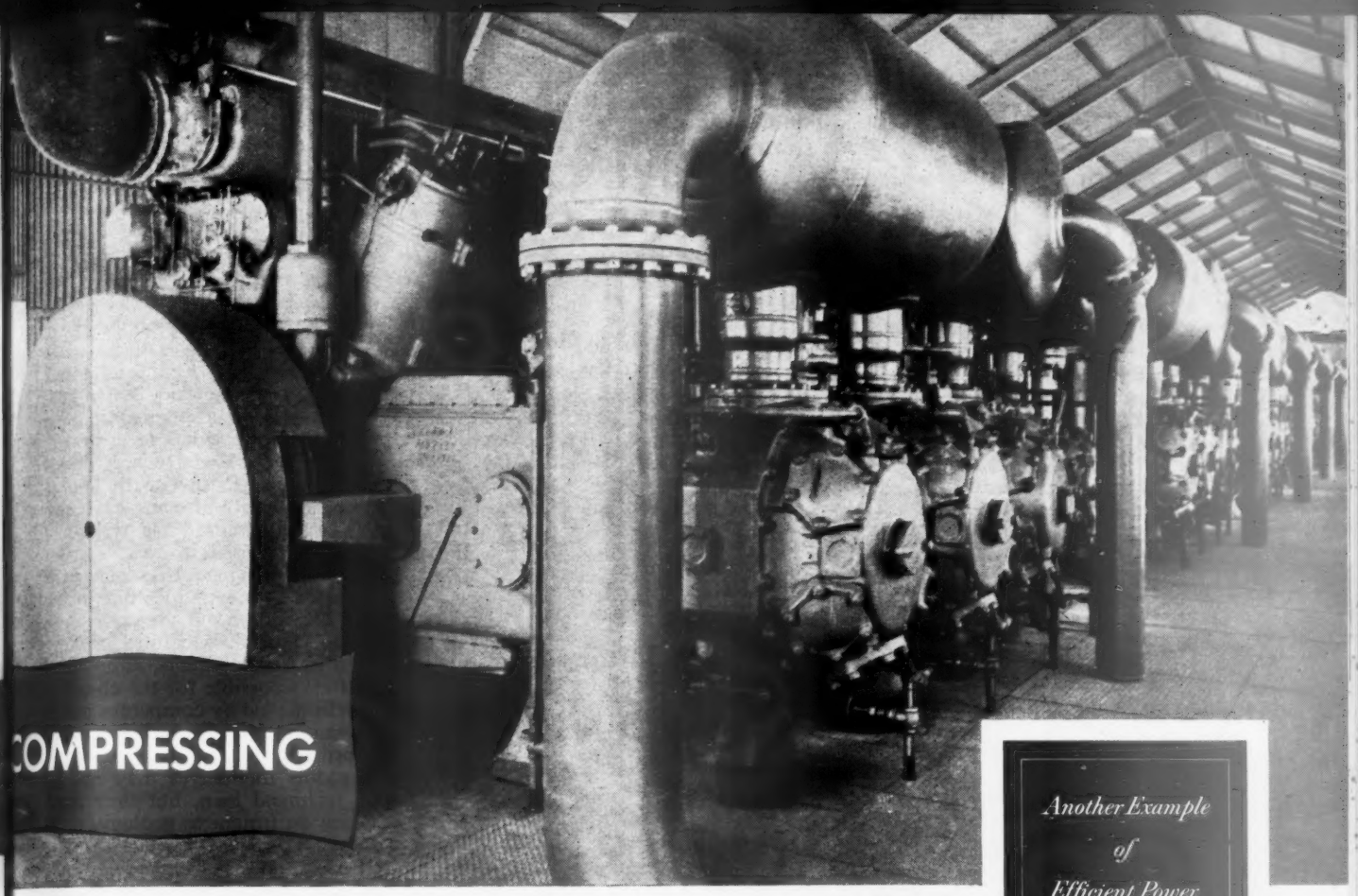
FOR ELECTRIC

Above: Some of the Cooper-Bessemer GMV's, now totaling 13,200 compressor horsepower, in the Diamond "M" — Sharon Ridge Gasoline Plant, Scurry County, Texas. *Below:* In this same plant 6 long-lived Cooper-Bessemer 375 horsepower gas engines drive generators for all electrical power requirements.

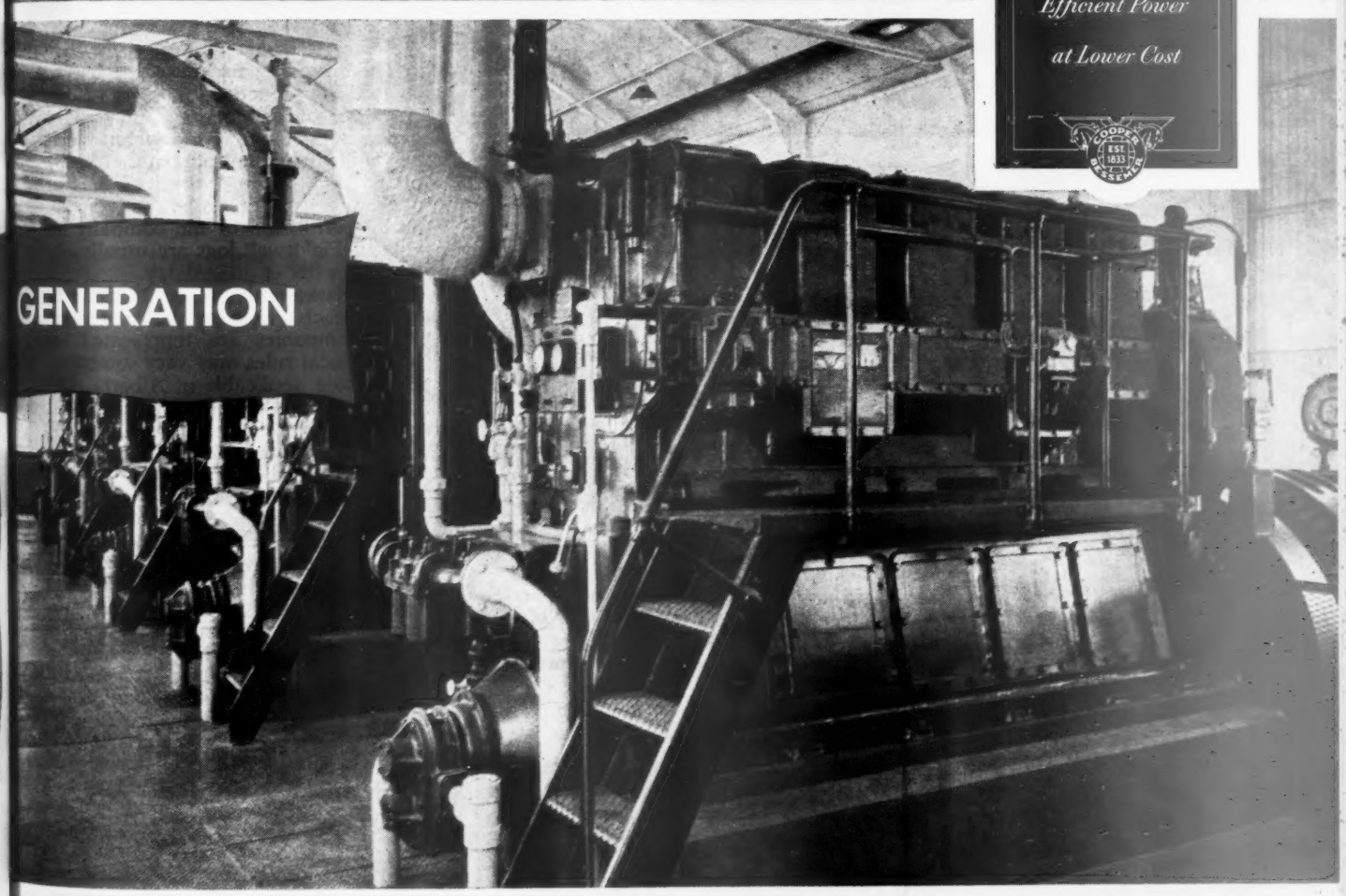
COMPRESSORS-GAS ENGINES-DIESELS

New York Washington, D. C. Bradford, Pa.
San Francisco, Cal. Houston, Dallas, Greggton, Pampa and Odessa, Texas Seattle, Wash.

XUM



Another Example of Efficient Power at Lower Cost



by Cooper-Bessemer

MOUNT VERNON, OHIO AND GROVE CITY, PENNA.

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valuable to the engineers who require those services.

Canadian Institute of Mining and Metallurgy

CIM is an old organization that always considered itself an organ of industry rather than a strictly professional group. About 1948 a move was made to form a Petroleum and Natural Gas Division and it got to the stage of functional operation about 1950. Since then it has had formal meetings of its own as part of the program of Western general meetings of C.I.M. or of the annual general meeting. In addition, dinner or evening meetings of the Calgary Branch have had addresses ranging from technical papers to subjects related to petroleum and natural gas in the business aspects. A meeting of the Petroleum and Natural Gas Division to be held in Calgary about next March is now being planned and it will be a two-day session.

It is the hope of the organization to follow a function somewhat parallel in Canada to the AIME in the United States.

Canadian Society of Exploration Geophysicists

Geophysical problems have local facets just as geological problems are local and the geophysical problems to some great extent are involved in those of geology. The Canadian Society of Exploration Geophysicists boasts a membership of 150 or more and on occasion they have joined forces with the geologists to present problems common to both skills and promote better appreciation of the limitations under which they work.

Scouts

The Western Canada Oil Scouts' Association is actually sponsored by some 36 companies, each of which may have anywhere from a single scout to quite an organization. Rather comprehensive rules govern what they do, but in general there is rather close liaison among them. For Alberta, scouts meet weekly on Wednesday at Red Deer, which is central for those in the north and in the south of the province and exchange data on drilling wells. Field wells and wildcats are covered in full. Various members are assigned to scout wells being drilled by companies not in the "check" and as a result the companies represented in the association are kept informed of developments, although it is not always possible for the check to cover wells drilled by companies not in the association if they decline to give out information.

The scouts themselves may not all rate as technical men, but they must have quite an insight to geology, drilling practices, services used and above all, tact, quickness of perception and loyalty to their own company organization and the rules governing what they may legitimately do.

The custom is for release of logs to Riley's Reproductions Limited within a month of completion. They make copies at half dimension which member companies may purchase. Usually others may obtain copies of logs of wildcat wells after a year has elapsed, or by permission of the company involved. Field well logs are usually obtainable without great delay.

For Saskatchewan, scouts meet in Regina each Thursday and much the same companies are represented although local rules may vary somewhat from those applicable in Alberta.

In 1955 a convention at Banff will bring together not only Canadian but American scouts from all oil countries.

Engineering Institute of Canada

Organized as the Canadian Society of Civil Engineers in 1887, the name was changed to Engineering Institute of Canada in 1917. It has as its aim, "To facilitate the acquirement and interchange of professional knowledge among its members..." and its branches cover all of Canada and its membership includes all phases of engineering work. The Calgary Branch holds evening meetings twice monthly except in summer, its lunch club meets every Monday except in summer, and these gatherings tend to promote contacts that are not limited to the oil and gas industry. Naturally with so diversified a membership its paper on oil and gas are of a more general nature.

Desk and Derrick Club

Perhaps the ladies of the industry do not claim pretensions to profes-

It takes a FULL team
...whether it's mushing
...or digging equipment
1. This is for big jobs
2. This is for medium jobs
3. Sherman for all other jobs
On many excavating jobs the use of big equipment is costly and time-consuming. The Sherman Power Digger is designed so that you get all the advantages of power digging on these jobs. Thousands of users have proved that the Sherman Power Digger reduces costs. Write today for descriptive literature S9.
Designed, Engineered and Manufactured Jointly by
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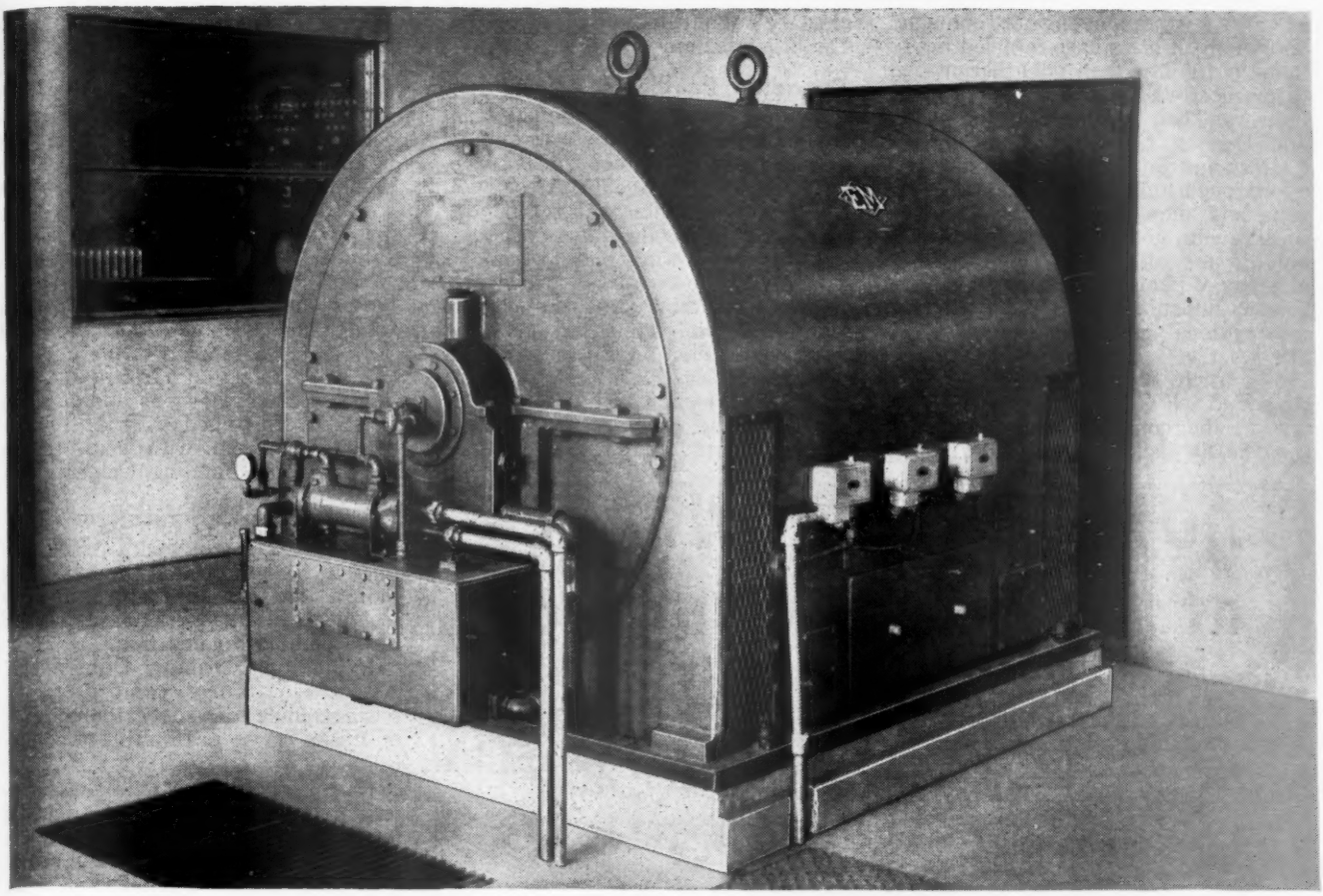
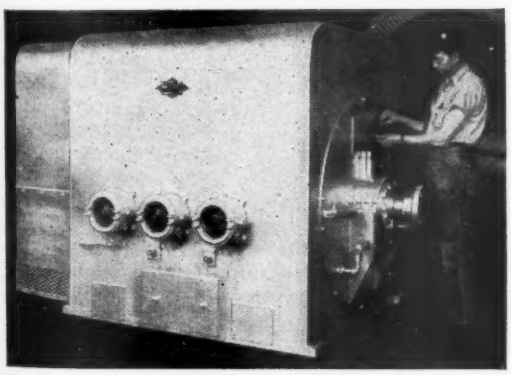


This Pipe Line Pumping Station Requires Less Space and Less Operating Personnel



This is a 1000 hp, 3600 rpm E-M Weather-Protected Induction Motor. Four motors of this type, which require no building enclosure, have been built recently for pumping application on a large pipe line system.

● One man . . . a master control . . . and four compact high-speed E-M Squirrel-Cage Induction Motors! That's the new electric motor drive system for the pumps at a recently modernized pumping station of one of the nation's large pipe line companies.

This electric motor drive replaces a former installation of large engine equipment. Total station space has been reduced by 50% and far less operating personnel are needed. Specially designed for pumping station operation, the four E-M Motors are on one side of a firewall . . . centrifugal pumps on the other. One man in the master control room supervises the entire station pumping operation. Only motor attention necessary will be periodic bearing inspection.

E-M installations such as this enable you to invest *less* in capital equipment for pumping, to save appreciably on operating costs, and to reduce maintenance down-time to a minimum. E-M has designed these economical Induction Motors with extra-strong coil construction for full-voltage starting. They are cool-running, self-ventilated and have a self-contained pressure lubrication system.

Take advantage of E-M's extensive experience in building large motors for pipe line pumps . . . for either indoor or outdoor service. See your nearest E-M sales engineer, and write direct for descriptive literature.

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Specialists in

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sional status, although our contacts with many of them have revealed mentality and skill in their field that makes them most valuable additions to the industry. Their organization, the Desk and Derrick Club, has branches in Calgary and Edmonton. Their dinners afford opportunities for personal contacts and they usually have a great speaker who gives the girls who work only in the office some idea of the meaning of items that otherwise would be only difficult words.

A national gathering of Desk and Derrick Clubs is slated for Banff in 1954, where the girls will have a chance to see some of the finest scenery on the continent and for those geologically inclined, the whole sedimentary column from the top of Pre-Cambrian sediments to recent.

Canadian Petroleum Association

Getting away, for the moment, from organizations that involve essentially technical or skilled men and women, the Canadian Petroleum Association is a live organization whose functions are largely to ease the impact of a new and rapidly growing industry on the economy of the country.

Shot hole crews go through the countryside and sometimes need to cross fields. Friction arises and in a meeting of farmers harsh words are used. Or farmers covet the royalties that go to the Province as owner of mineral rights, and resolutions are passed. These and many similar matters call for public relations between the industry and the public. Casing and other materials may be in short supply leading even to national allocation of steel. Tax concessions may be needed. Here it is not so much public relations that are needed, but constructive explanation to government bodies.

Starting as the Alberta Petroleum Association with fairly modest staff, the organization later became Western Canada Petroleum Association, and now is Canadian Petroleum Association with provision for Provincial or other local subdivisions and it serves a most useful function. R. H. C. Harrison is president, with head office in the Petroleum Building, Calgary.

Other Organizations

The Alberta Landmen's Association involves a group that perhaps runs more to lawyers, but involves a highly technical line of work. Saskatchewan has a parallel organization.

Exploration Drilling Contractors' Association brings competitors for business under one roof, although it by no means serves in restraint of competition.

Calgary Petroleum Club has quarters in rented premises and a backlog in the building fund of $170,000 plus a down-town site for a building of its own. The place is a popular place for lunch and somewhat less crowded for dinner and evening parties. Its membership is 1300 and involves other than oil men. With assets of $350,000, it is something to reckon with.

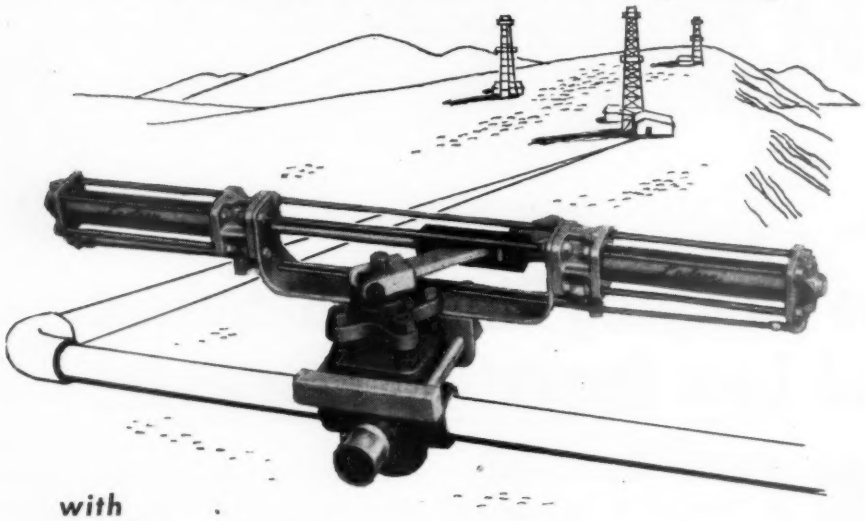
Association of Professional Engineers

Under Canadian law each province has control of licensing professional men within its boundaries. Alberta led the other provinces with an Act passed in 1920 governing engineers. Only with time and amendments to the original Act has the licensing become really effective. Engineers from outside the province who wish to practice may obtain license although membership in the Association requires Canadian citizenship. Other provinces of Canada have parallel associations with much the same requirements.

Summary

Along with the phenomenal growth of the oil and gas industry in Western Canada there has grown up an equally remarkable lot of organizations. In one of the most competitive industries, the progress of interchange of knowledge has proved to those who wish to observe it, that assistance to the other fellow pays off dividends. He who helps is himself helped in the long run. The multiplicity of organizations has proved to be beneficial by aiding in specialization. Some of us belong to several of the organizations, it is true, but that seems to be unavoidable and we can see that if any one of the groups were to try to cover all phases, some values would be lost. ★ ★ ★

AUTOMATIC CONTROL
of Flow and Gauging



with
Ledeen VALVE ACTUATORS

The Ledeen Tandem Type Actuator, illustrated above, is a pneumatically or hydraulically operated unit for direct or remote control of standard plug valves. It is a package unit and is mounted directly on the valve without need of any special manifolds or outside supports.

★ Direct or Remote Control.
★ Automatic Processing.
★ Safety Installations.
★ Multiple Central Control.
★ Ledeen Valve Actuators are available for operation of Gate, Diaphragm, Plug and other Flow Control Valves.

This tandem actuator, with two cylinders working as a unit, delivers positive, smooth and balanced torque to the valve stem. The balanced design eliminates any cantilever load on the body or eccentric load on the stem.

Because it is a package unit, this actuator can be installed on a valve in any position—easily, quickly, rigidly and without interrupting production. It requires a minimum of maintenance. WRITE FOR BULLETIN 3000.

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VALVE ACTUATORS
AIR HYDRAULIC
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LOS ANGELES 15, CALIFORNIA

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First there's financing by the FIRST in Dallas

the Southwest's Pioneer Oil Bank

FIRST NATIONAL BANK IN DALLAS

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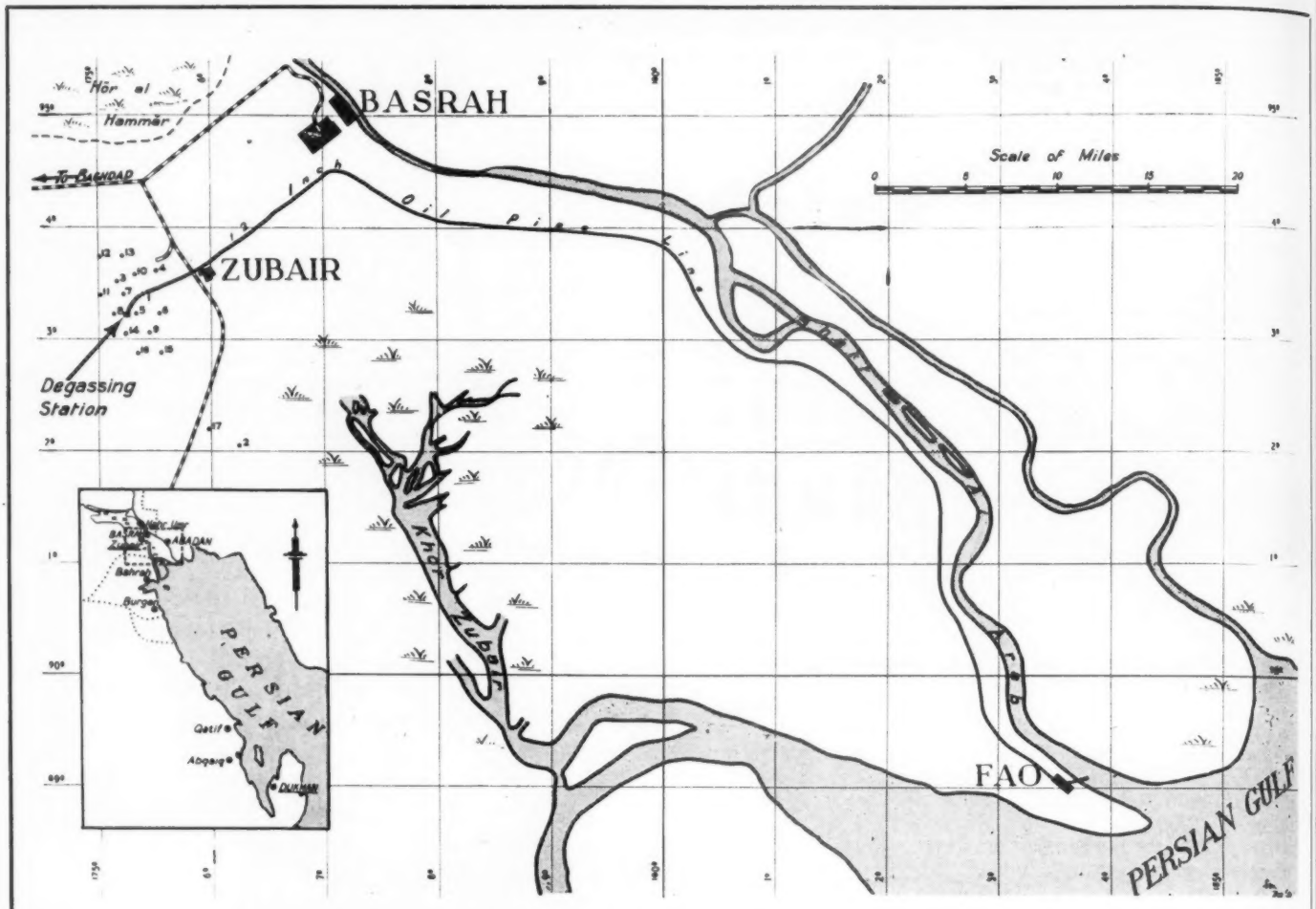
Give us an opportunity to say YES



SCHEDULED for completion before end of 1953 is a 24-in. pipe line that will run parallel to 12-in. line from Zubair to Fao.

Iraq Zubair Oilfield Development

Fifteen wells producing in area now; more completed wells to begin production when 24-in. pipe line goes into operation

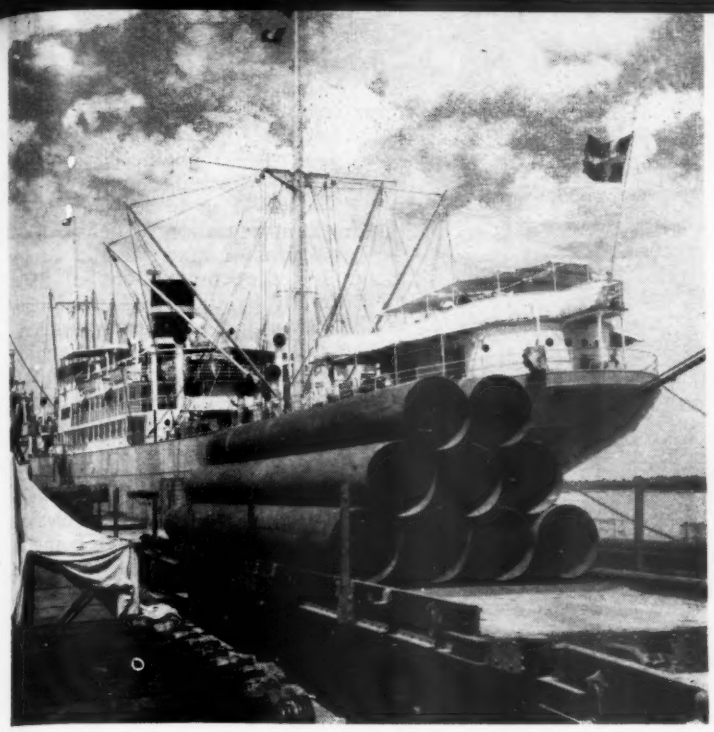
V. S. SWAMINATHAN

THE Government of Iraq granted to Basrah Petroleum Company (BPC), an associate of Iraq Petroleum Company (IPC), a concession over southern Iraq (south of latitude 33) on the last day of November 1938 for a period of 75 years. Geological exploration began immediately, and prior to outbreak of the second world war extensive work had been done in the Amara area. During the war orders were placed for drilling equipment in Britain and BPC obtained the first deep drilling outfits manufactured in the United Kingdom soon after that emergency. Later an intensive geophysical survey, employing gravity, magnetic, and seismic techniques, was carried out in the southern area of the concession.

As a result of these surveys a number of potentially oil-bearing structures were located of which the only surface expression was a slight elevation, the area being overlain by recent sands and gravels. Test wells were located on the most promising of these structures —at Zubair, Nahr Umr, and Ratawi. That at Zubair was near the crest maximum of a very gentle anticline trending north north-west to south south-east, some 20 miles west south-west of Basrah.

EXCLUSIVE

Makinah was developed as a base for field operations, and construction of buildings commenced at Zubair and Nahr Umr where test wells were located. A deep drilling outfit was brought in on February 14, 1948. On March 17 of the following year drilling ceased on reaching a depth of 11,171 ft and on May 4, 1949 a valve at the well-head was opened and oil started flowing to the surface. By the end of 1950 four drilling rigs were working in the field. Following satisfactory tests for quality and quantity, it was decided to develop the area around Zubair No. 1 for an initial annual production of 2,500,000 long



SECTIONS of 24-in. pipe line for new 75-mile Zubair to Fao line is unloaded at Basrah dock.

PIPE near Abu Flus is cleaned for second time and first protective coat is applied.

tons. Six drilling rigs were employed, and wells drilled on a 1¼-mile grid spacing surrounding the discovery well.

The geological section revealed by drilling was as follows:

Age	Local name of formation	Description	Thickness in feet
Miocene	Dibdibba	Sands, gravels.	900
	Lower Fars	Gypsum, marls, limestone.	600
	Abu Ghar	Sands, gravels.	500
Eocene	Bahrein	Limestone, locally dolomitic.	700
	Rus	Anhydrite with limestone.	400
	Aidah	Marly limestone.	1500
Upper Cretaceous	Aruma	Marly and chalky limestone with marls and shales.	2600
Middle Cretaceous	Khatiyah	Marls and limestone.	1600
	Mauddud	Limestone.	500
	Nahr Umr.	Sandstone and shale.	1000
Lower Cretaceous	Shu'aiba	Limestone.	200
	Zubair	Sandstone and shale.	600

The Zubair oil field produces 35 API gravity crude from a Lower Cretaceous sandstone, designated the third pay, from a depth of approximately 11,000 ft. The fourth pay, another Lower Cretaceous sand, some 300 ft below, yielded oil of 43 API gravity in Zubair No. 24.

The second pay consists of a Middle Cretaceous limestone with 26 gravity crude and 3.8 per cent sulfur at 7000 ft; the first pay is a heavy asphaltic crude of 20 API and 4.5 per cent sulfur, in Lower Fars limestones and sands at a depth of about 1000 ft.

Zubair has been proved for a length of 22 miles but the two ends have not yet been delimited. The dome under production and active exploitation is Shu'aiba and is defined over a distance of 12½ miles with a maximum width of 2½ miles.

Two other structures—Nahr Umr and Ratawi—were tested in 1947-48 and a fourth—Rumaila—is now drilling. Nahr Umr got lighter oil (42 API) with high gas-oil ratio in Middle Cretaceous sands in the first well, but in the second these were water-logged, defining a small dome possibly of salt origin. This upper sand was water-logged in Zubair. In Ratawi all three sands showed heavy oil with water underneath but at the bottom of the hole in an Upper Jurassic limestone, a gas show was struck below 12,000 ft.

In this Basrah concession 90,833 ft were drilled in 1951 bringing the cumulative footage drilled to 202,424 ft. In that year drilling effort was concentrated in the Zubair field so as to start shipment of oil at the earliest possible moment. Six drilling outfits were employed and 7 wells completed during the period at depths between 10,000 and 11,000 ft, and at the end of 1951 five more were drilling. A factor contributing to the increased footage was the reduction of time spent in moving derricks from one location to another, which on three occasions were skidded for distances of from 1½ to 3 miles. Five drilling rigs continued throughout 1952 in active operation in the Zubair field. During the year 109,203 ft were drilled, 10 wells were completed and 6 were in progress at the end of the period.

A total of 30 producers has been drilled (866-acre spacing per well) and a recent one down flank to the fourth pay. Average completion depth for third pay producers is around 11,000 ft, where 5½-in. casing is set on bottom and perforated (now with shaped charges) opposite the principal sands. The number of bullets used is 1000 and shaped charges used is 800; the drilling time in early 1953 was 100 days, and the closed-in pressure just over 2000 psi. The gravity of crude is 35 API—the highest wells and upper parts of the sand yield slightly lighter oil, so that iso-gravity lines follow the contours of the Shu'aiba dome.

For the first time in the history of the IPC group a complete derrick was moved on wheels from one site to another without being dismantled, with the employment of specially manufactured equipment in early 1953. This involved transfer of the rig from Well No. 25 to another location on the Zubair field.

The initial part of the operation consisted of moving the derrick—a 136-ft high pyramid of steel, weighing 70 to 80 tons. Steel brackets were fitted to the derrick sub-structure, after which three 4-wheeled bogies, equipped with 30-ton electrically and manually operated hydraulic jacks, were moved into position underneath. The jacks were then operated, and the entire derrick was raised a foot above ground. At this stage a Caterpillar tractor was connected to the leading bogie and the derrick towed to its new site at a brisk walking pace. The rig engines and drawworks, supported by their substructure, and the mud storage tanks and other equipment, were shifted separately by the same technique in two further operations.

A major improvement on the skidding method used previously, this "rig on wheels" technique was developed by T. S. Coggan, assistant fields manager; J. B. Williams, equipment engineer; J. C. Taylor, rig erector, and Ian Scott, chief engineer, Oilwell Engineering Company, Ltd., of Stockport, England. Normally it takes up to 12 days to dismantle a rig over a completed well and re-erect it on a new site, but now that the rig on wheels technique has been perfected, the entire operation can be carried out in a few hours.

In early 1953 fifteen Zubair wells were feeding oil through No. 1 degassing station from which it was pumped down the 12-in. pipe line to Fao. The rest of the completed wells will begin producing later in 1953 when the new 24-in. pipe line will come into operation.

Four wells are being drilled near Hor Al Hammar Lake, and the site for the fifth has already been chosen. Also,

A 19-RB excavator digs trench for new 75-mile, 24-in., Zubair-Fao pipe line in swampy ground near Abu Flus. Surface 12-in. pipe line and outer fringe of date palms can be seen in right background.

5 locations have been fixed for future operations in the northern sector of the field where bulldozers are busy bunding thousands of tons of soil as a protection against floods. It is computed that with the same number of drilling rigs in operation, 130,00 ft will be drilled in 1953 compared to 109,203 ft in 1952 and 90,853 ft in 1951.

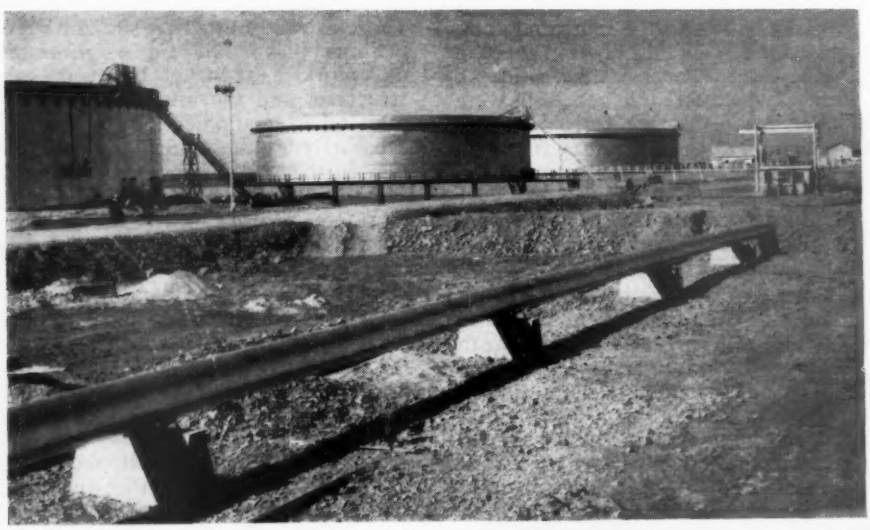
Plans for the immediate future include: (1) completion of the new 24-in. pipe line with ancillary installations to step up oil shipments to 8,000,000 long tons a year by the end of 1955, a figure markedly in excess of the 1953 target of 2,800,000 tons with the 12-in. line working to capacity; (2) a second degassing station at Seeba, half-way between Zubair and Fao, complete with flow tanks, feeder lines and pumps to handle oil from four completed wells north of Zubair No. 1 and any others ready for production before the end of 1953; (3) an electric power station to supply electricity to the entire field before the close of 1953; and (4) a third degassing station to be built still further to the north to be ready in 1954.

The export of Zubair crude inevitably entailed erection of field installations, storage tanks, a power station, and workshops; stores, offices, commissariat, and transport depots at Makinah; and last but not least, a 70-mile, 12-in. pipe line to Fao, and at this terminal, storage tanks, pumphouse and loading jetties. The expenditure incurred before the first tanker left the jetty exceeds £ 50 million. Provision of all these services necessitated the importation of nearly 100,000 long tons of material and equipment, and the employment of 2500 men directly by the BPC, in addition to those working for the contractors.

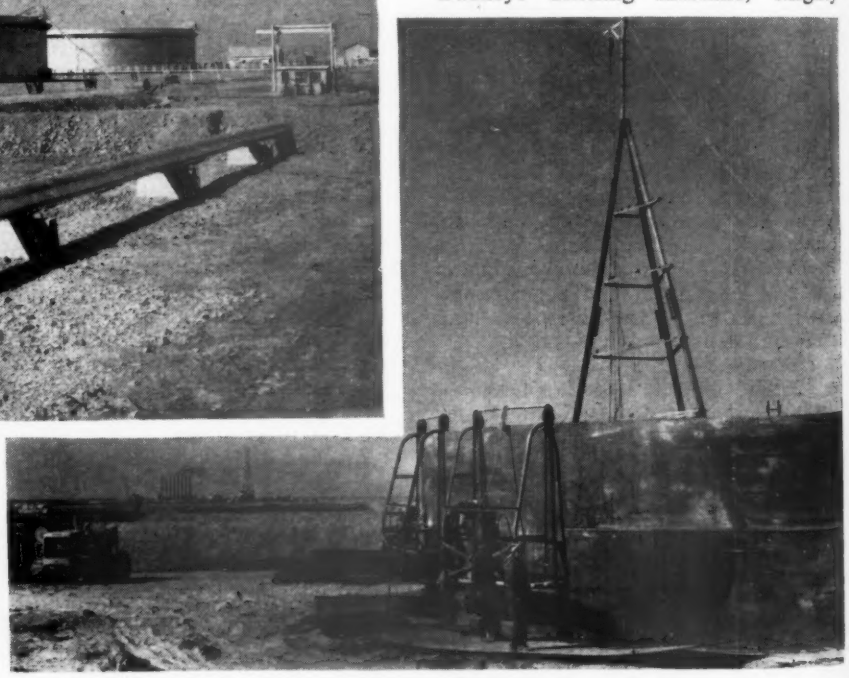
The initial single degassing station installed in a central position with reference to the 15 producing wells and making use of horizontal separators, stabilizes the crude oil. The oil and associated gas flow through individual high pressure flow lines from the wells to the station, where the gas is released in 5 stages, the ultimate stage being to the flow tanks. From the latter the stabilized crude is transferred by a small centrifugal pump to 3 large storage tanks from which it is pumped through the 72-mile line to Fao by 4 gas-driven and 2 diesel-driven pumps. The pipe line is 12-in. in diameter, except for the last 10 miles which is 16-in. The line is laid on 8 ft concrete sleepers, expansion and contraction being compensated for by movement in a vertical plane.

Work on laying the 65-mile 24-in. line from Zubair oil field to Fao terminal at the head of the Persian Gulf made steady progress during the summer of 1953. From the field the new pipe line follows an easterly course for 16 miles to the village of Hamdan, where it turns south and for 6 miles runs parallel to the belt of date palms on the southern bank of the Shatt-al-Arab River. It then cuts across the desert for 13 miles until it meets the main road at Seeba, headquarters of the pipe line construction gangs, whence it follows the road for the remaining 30 miles to Fao.

Laying this 24-in. line was not without its difficulties. The pipe line team was faced with the problem of transporting heavy equipment like the Buckeye ditching machine, Mighty



Tank farm at Fao.



NO. 2 DEGASSING station is under construction. Steam rig is in rear.

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International U-450 provides 13,965 hours of pump jack proof

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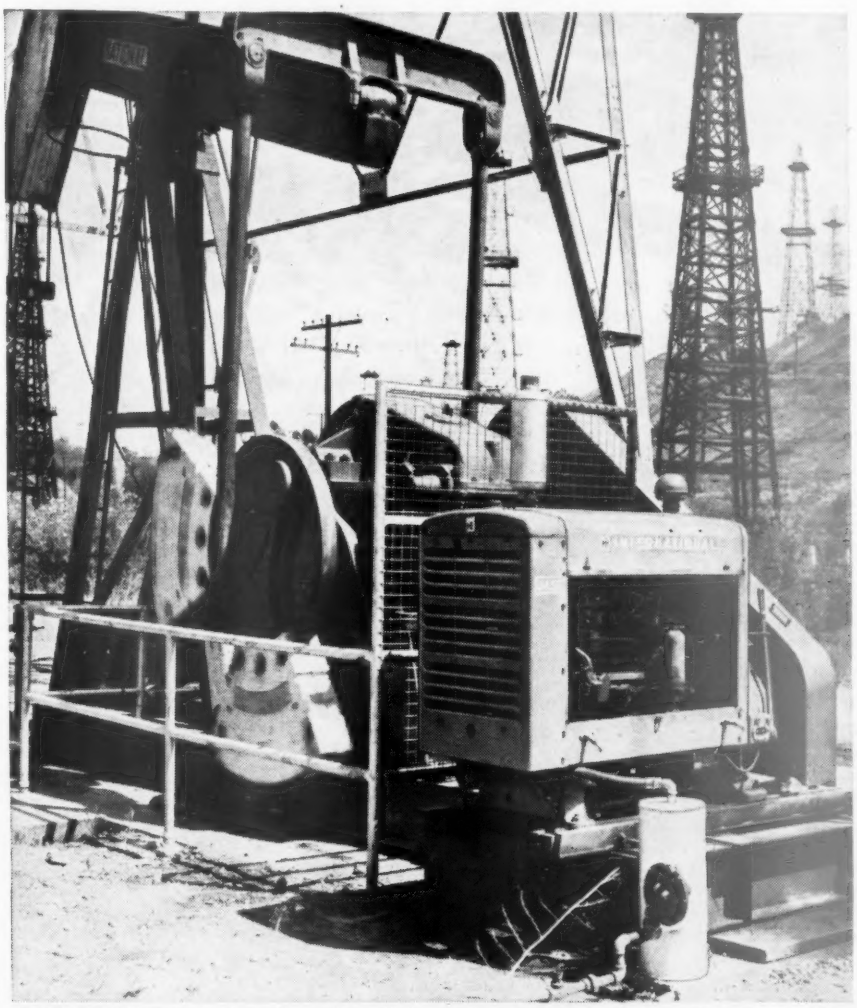
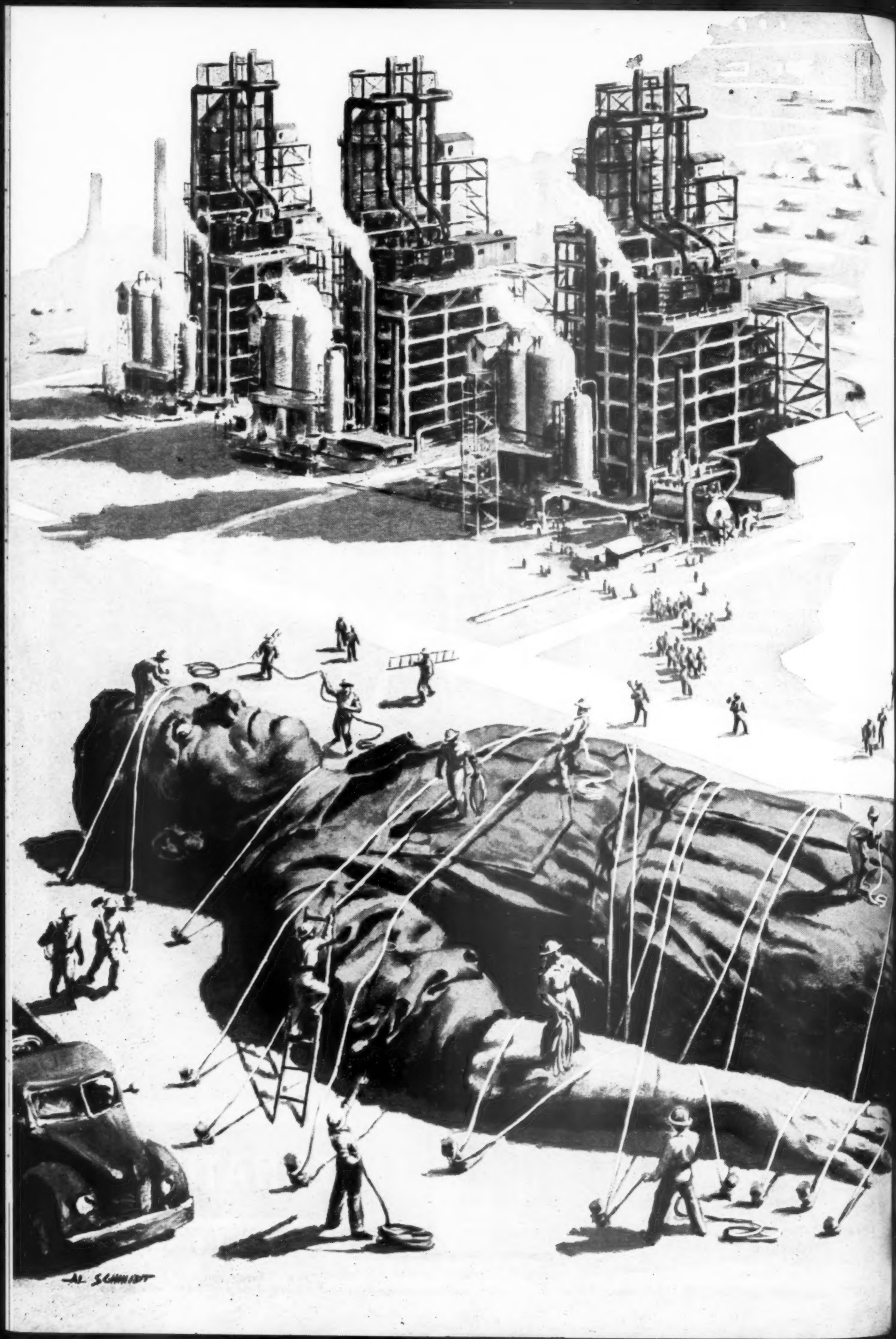


ONE OF 23 International engines doing a tremendous oil pumping job in this California canyon is this new natural gas U-450 six-cylinder engine.

INTERNATIONAL HARVESTER

INTERNATIONAL

POWER THAT PAYS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They *did* make this new source of energy available to all the people.

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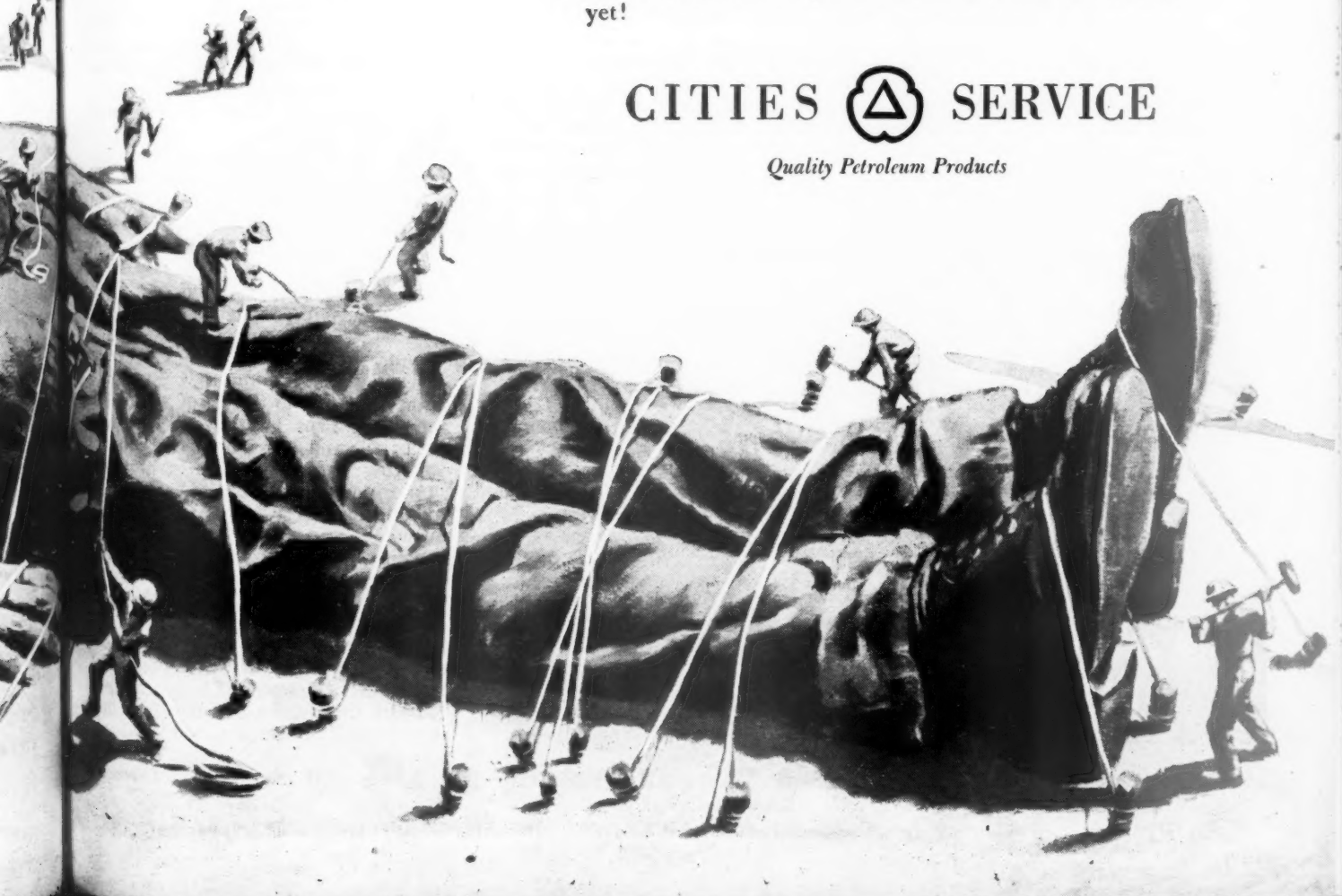
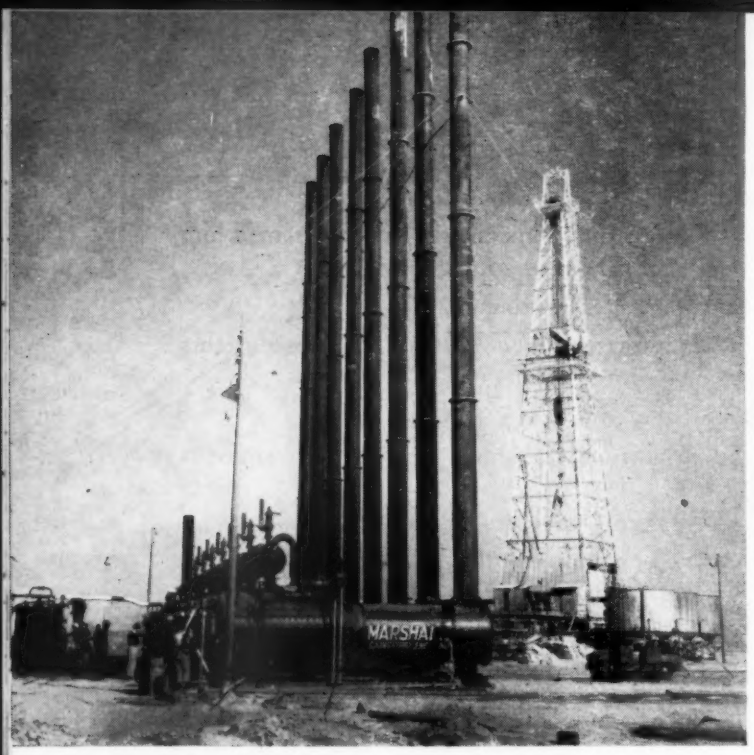
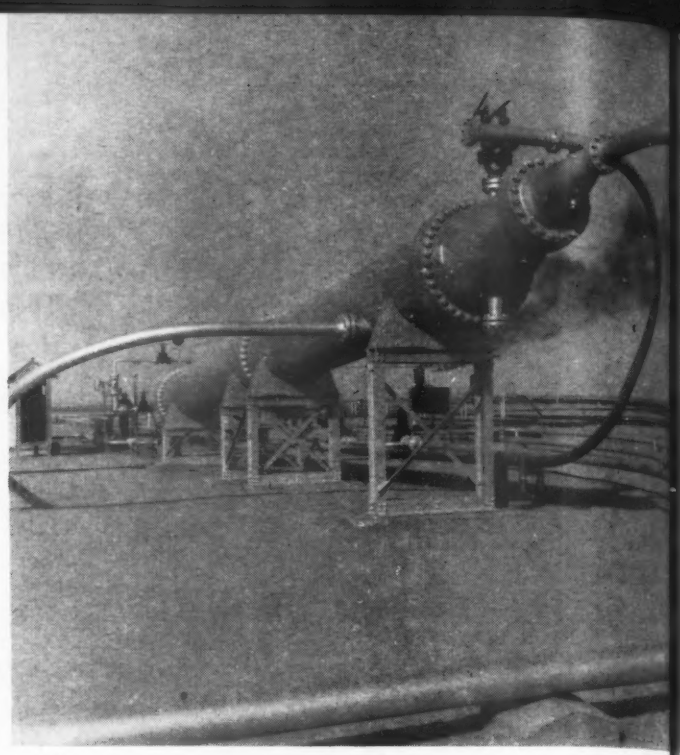




BATTERY of boilers provide steam power for operating rig at Zubair field.



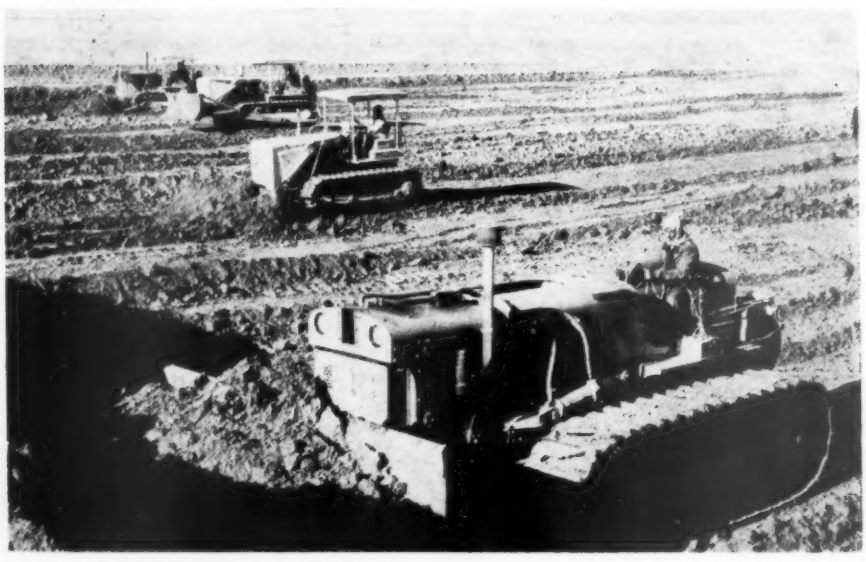
HORIZONTAL separators used at Zubair Oil field of Basrah Petroleum Company.

Antars, bulldozers, tractors and workshop trailers from Basrah to Seeba for work on the southern section of the line. These could not be driven because the bridges were incapable of bearing their weight, nor cope with their size. Moreover, there were floods. So, all the heavy equipment was loaded onto barges with floating cranes and transported down the Shatt-al-Arab to Seeba where it was unloaded and delivered to the pipe line construction camp. In the same way much of the pipe itself was barged down the river to Seeba and Fao where stockpiles were set up in readiness for laying.

Earlier, 21 miles of 26-ft lengths of pipe were welded into 52-ft lengths at Zubair, where they were transported by road. Manufactured by the South Durham Steel and Iron Company of England, the pipe was delivered in 24 consignments comprising a total of 15,630 joints weighing 17,614 tons.

The biggest headache, however, was the underground percolation of water from the Khar Abdulla and the Shatt-al-Arab, and the resultant malleability of soil. On the last stretch to Fao, for example, water a foot beneath the surface had to be pumped out of the ditches before the pipe line could be laid. To make matters worse, the 35-ton Buckeye ditcher and some of the big tractors sank into the soft silty soil. Mechanical breakdowns, stemming largely from the nature of terrain traversed, also hindered progress on occasions, and with a temperature of 120 in the shade machinery became too hot to touch when fitters attempted to repair it.

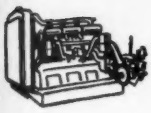
BULLDOZERS are engaged in earth bunding operations at Hor al Hammar, Zubair, as a protection against flooding.

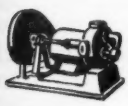


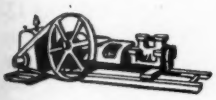
To overcome these difficulties adaptions were made on site to the Buckeye ditcher, which digs a trench 4 ft wide and 4½ ft deep, and averages just over a mile a day under favorable conditions. Digging in soft muddy soil, the huge smooth-surfaced front wheels and driving tracks of the machine churned round wildly and continued to do so until sharp teeth of steel had been fitted so that they could grip the ground. Tines or prongs were also fitted on the back of the digging buckets so that water could drain through and steel blades were attached to the sides of the ditcher to flatten the top of the ditch and prevent the loose, saturated soil from sliding in.

By April 1953 eight miles of the new pipe line had been strung, welded, wrapped, and buried in high ground south of Zubair; but, because of floods the remaining 8 miles to Hamdan were not attempted at the time. By mid-June, however, the stretch had been cleared for ditching and it was proposed to leave it until the scorching summer sun had dried it out. It would form the last section to be tackled. From Hamdan to the point where the pipe line turns away from the date palm belt and cuts across the desert, stringing was carried out in preparation for laying in July. The next 31 miles (most of it across desert) has been laid and buried and work proceeding apace on ditching, welding, cleaning, priming, and doping of the few remaining miles to Fao. July 12 saw the completion of the first 50 miles, leaving just over 15 miles of strung pipe to be welded, coated, and buried in the desert area between Abul Khassib and Zubair. The new pipe line is expected to be finished well on schedule.

Nearly 500 men, some of whom







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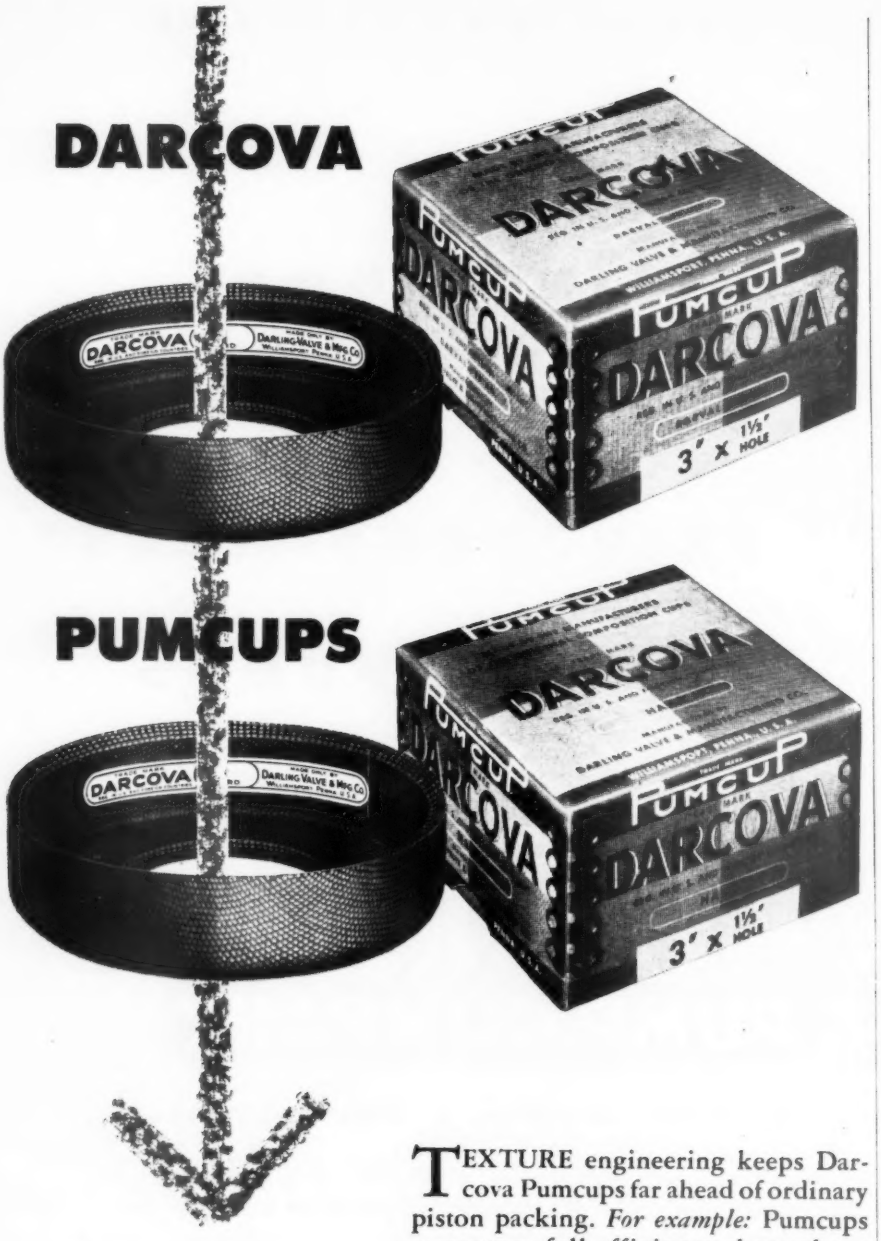

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helped to lay the 16 and 30-in. pipe lines from Kirkuk to the Mediterranean coast, are on the job. All are employees of the company, and most are accommodated in tents at Seeba, equipped with beds, tables, chairs, wardrobes, and electric lights, while showers, modern kitchens, and messes with water coolers and electric fans lie close at hand. There is also a small hospital and a canteen operated by a contractor. Running water is supplied from two 5000-gal tanks filled by a water barge moored in the river, and equipped with purification and filtration plant, while an electricity supply provides power for almost everything including radio sets, toasters, air-conditioning, and an electric iron used in the laundry tent. This new line will, with the existing 12-in. pipe line, enable BPC to step up exports of Zubair oil now running at an annual rate of 2,900,000 long tons to 8,000,000 tons by the end of 1955.

For a start, at the Fao terminal 8 crude storage tanks were erected, each with a capacity of 4¾ million imperial gallons. Two oil loading jetties were built, each of which can load at a rate of 2000 long tons per hour by means of electrically-driven loading pumps. There are also a power house with three 640 kva generators, a water treatment plant with a daily capacity of 120,000 gal, a boiler house supplying the tankers with steam and worker's living quarters.

The first tanker loaded at Fao with Zubair oil on December 19, 1951, nine months ahead of the original target date. The average daily production of oil in January 1952 of 1,974 long tons rose by December to 8150 tons, and the reservoir gross cumulative total from 206,159 tons at the end of January to 2,353,146 tons at the close of the year. Exports from Fao, which in January were 54,282 tons, had by December risen to a monthly rate of 216,344 tons. The M. V. *Antarctic Tanker,* which left Fao on July 4, 1953, with a cargo of 11,563 tons of Zubair crude was the 300th ship to load at this southern Iraq oil port. With this shipment oil exports by BPC from Fao totalled 3,615,654 tons, of which nearly 1,500,000 tons were exported during 1953.

Late in 1953 a new pumphouse will be installed with electric-driven pumps brought by rail from Kirkuk to put oil through the 24-in. line. At Fao 2 further jetties and 12 more 4¾ million gallon storage tanks are nearing completion.

At the inaugural ceremony held in early January 1952, H. S. Gibson, managing director BPC, pointed out that the rapid development of oil fields has all too frequently been accompanied by boom conditions which have seriously distorted local economy. He assured that it was the very definite policy of his company to maintain a uniform level of employment in its operations and so make a major contribution toward the prosperity of the people of Basrah forming a valuable element of stability in the economy of Iraq. * * *

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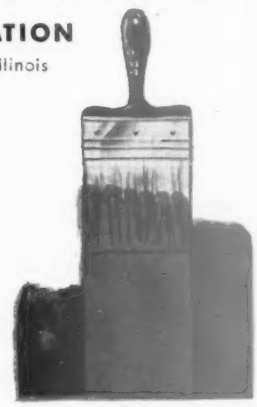

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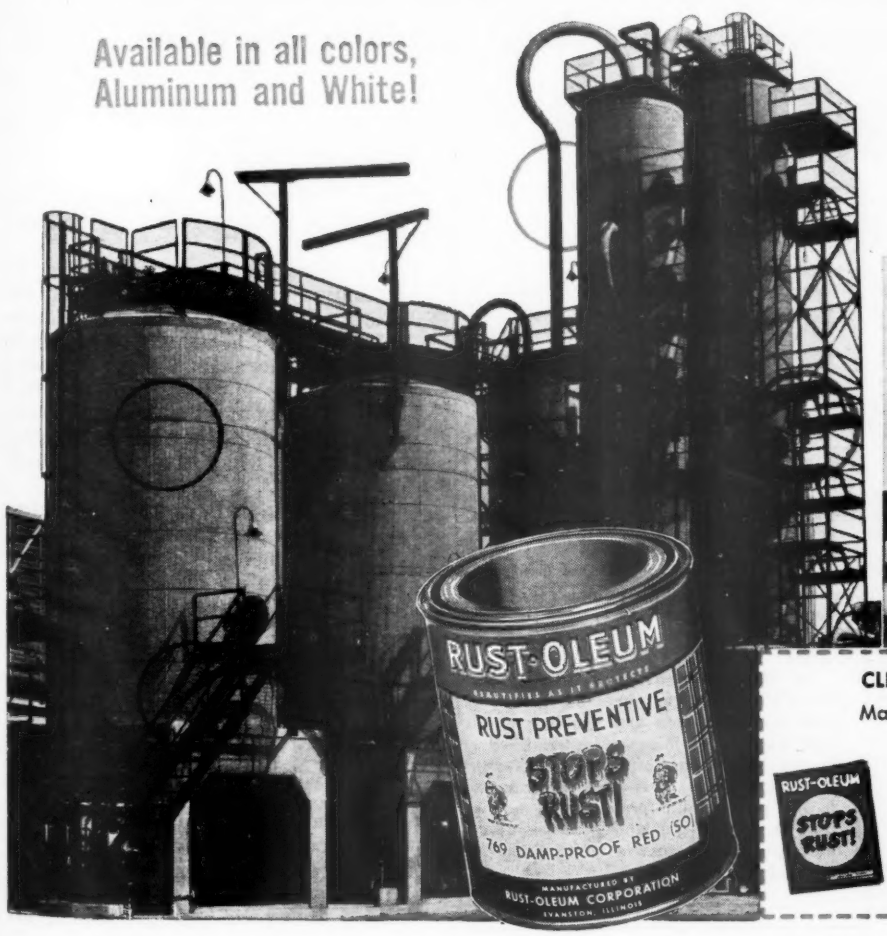

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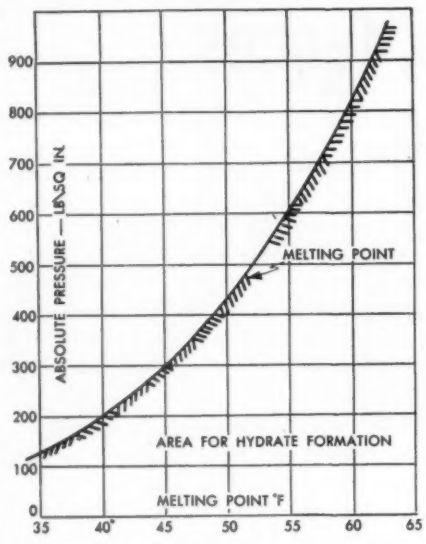

FIG. 1. MELTING point of natural gas dehydrate.

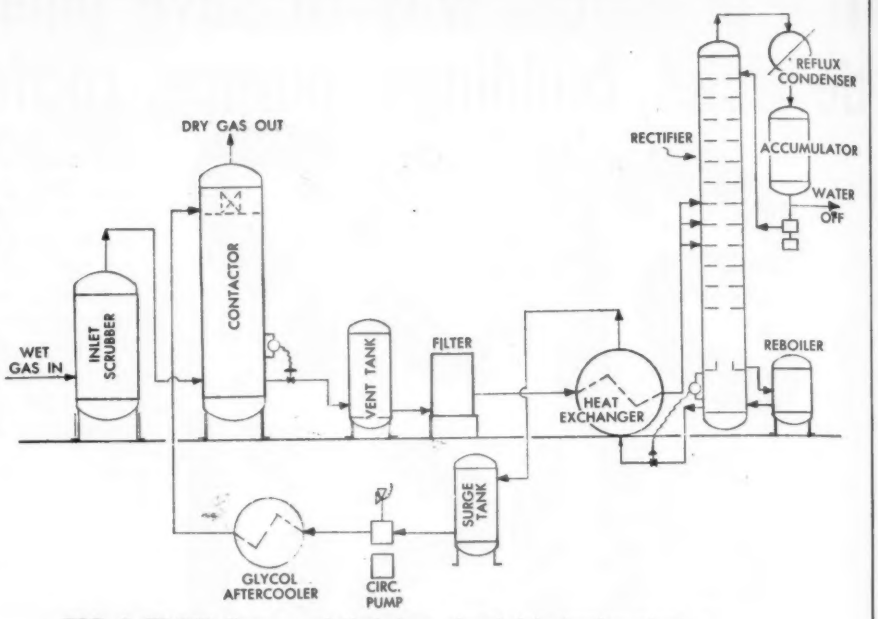

FIG. 2. FLOW diagram of diethylene glycol dehydration plant.

Design and Operation

Liquid Desiccant Dehydration Plants†

Particular problems faced by operators of natural gas dehydration units are presented here and successful remedies are given

J. A. GORDON

GAS hydrates are defined as chemical compounds composed of natural gas hydrocarbons of methane, ethane, propane, or iso-butane combined with water in a fixed molecular proportion, usually about six or seven molecules of water combining with one molecule of hydrocarbon. They are in appearance a white snowy mass with well defined crystals which usually pack into a nearly solid mass resembling ice or snow having a honey combed appearance in cross-section. They generally form in regions of high turbulence, and once started, usually form at a rapid rate. Hydrates often occur on the upward slope of a line immediately following a sag, or at the junction of laterals with the main line. Valves, meter runs, or other restricting fittings are often the points at which freezing occurs. These points may be detected by a characteristic singing of the gas or in some cases it is possible to obtain an excessive pressure drop between two points of measurement.

There are several methods for inhibiting the formation of hydrates which includes: (1) reduction in pressure, (2) increased temperature, (3) addition of inhibitors and (4) dehydration.

Pressure and temperature affect the formation and also the removal of hydrates. Fig. 1 illustrates this relationship for a typical natural gas. It can be seen that the shaded area represents temperatures and pressures at which hydrates form and that the line boundary of this area represents the melting point above which hydrates normally do not exist.

One method of combatting freezing is to reduce the line pressure to the corresponding melting point temperature as shown on Fig. 1. This method is slow and is limited in its application as it can be employed only in areas operating under high pressures and a small temperature range. The system must be above 32 F, however, or the released water will freeze into ice. Also this system is excessively expensive.

Another method of eliminating freezing is to raise the temperature above the melting point shown on Fig. 1. This commonly done with hot water bath or steam jackets for meters, valves, and piping above ground. Buried lines have been exposed in bell

The Author

J. A. Gordon received his BS in engineering from University of California at Berkeley in 1941. He served his trainee period while working for Associated Oil Company in 1941 and 1942. In the latter part of 1942 he joined the Union Oil Company of California, working as an engineer in the core laboratory and as a field engineer specializing in oil and gas problems.

In 1946 he was transferred to Union's head office, where he specialized in natural gas and gasoline operations. During this period he aided in the installation and operation of the first package type gas dehydrators in the state of California. He is now Union's natural gas and gasoline department's representative in the Southern and Ventura divisions.

†Presented before the California Natural Gasoline Association, October 9, Los Angeles.

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holes and heated with fires fueled with oil, gas, wood and brush.

Another method of removing hydrates is by the introduction of inhibitors into the gas stream. Principal hydrate inhibitors in use include methyl alcohol, anhydrous ammonia, and calcium chloride brine. These chemicals are high in cost and they are rarely recovered and they are often difficult to place in the line at the proper location.

Dehydration lends itself best of the above methods for hydrate control and the following discussion relates to basic operating problems with glycol gas dehydrators.

Glycol Dehydration Plant

In a typical diethylene glycol plant as shown in Fig. 2, the gas passes through an inlet scrubber which removes any entrained liquids and then enters near the bottom of the contactor where it passes upward through a series of bubble trays and contacts the glycol solution which enters the top tray flowing by gravity across the various trays. The gas continues upward through the contactor where it is scrubbed and passes out the top as dehydrated gas. The water enriched glycol enters a liquid sump at the bottom of the contactor and from here it passes through a liquid level controller into a vent tank where hydrocarbon condensate and other gas contaminants are separated from the glycol. Next the glycol solution passes through a filter where any solid material is removed and then to a heat exchanger where it picks up heat from the hot lean glycol from the stripper. From the exchanger the rich glycol passes to a reboiler where it is heated to the required temperature by either direct fire or steam. The hot glycol then enters the stripper and is fractionated, the water coming off the top and the lean glycol going to the bottom where it leaves the stripper and heats the rich glycol to the stripper in the above mentioned heat exchanger. From here it passes to a surge tank and then to a pump which pumps the glycol to the contactor completing the cycle.

Dew Point Determination

Successful control and operation of dehydration plants is dependent upon a suitable method of determining the water content and the dew point of the treated gas stream.

Some operators rely mainly on calculations of actual water removed by assuming the gas to be saturated. The water contents of the lean and rich glycol streams are determined and the difference is correlated with the glycol and gas rates using a water content versus pressure correlation for saturated gases. Inaccuracies in this method are in the sampling of the glycol and the use of the water content curve which at best is a composite of a number of gases and is, therefore, only approximate.

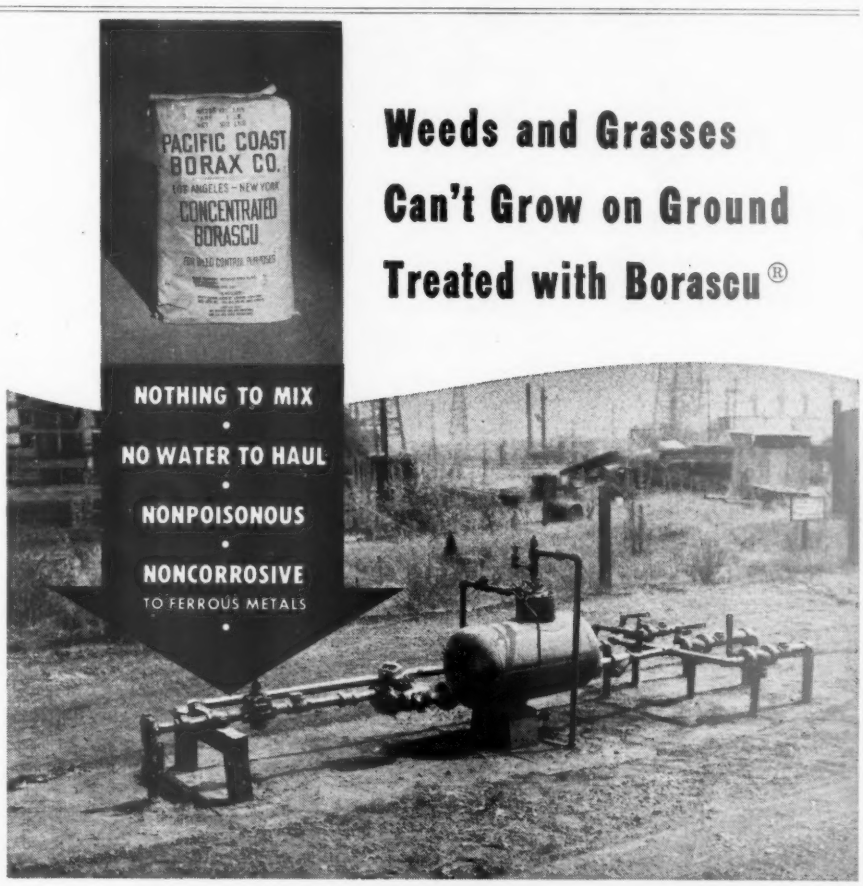
The most extensively used method for dew point determination is the Bureau of Mines dew point indicator. It is best known because of its simplicity and portability and experienced operators can check readings to within one degree. This instrument is described in detail in the literature and, therefore, will not be described here. It has one main operating difficulty in clearly defining the actual dew point as hydrocarbons condense on the mirror and cause concentric rings to appear which make more difficult the detection of the gray spot characteristic at the hydrate point.

The difference in composition in gases and the method of dehydration also influence the formation of these concentric rings or flooding of mirror.

This difficulty can, however, be largely overcome as the operator gains experience and also by taking several readings, one fast to determine the approximate range of the dew point, and another one or two running slowly in the above-determined range of accuracy and correlation.

Dew Point Control

The proper dew point control is often overlooked in the operation of gas dehydration plants. This is usually due to lack of experience, especially in the operation of the smaller package type units which almost always operate unattended. In these cases, the dehydrator is usually operated at maximum glycol temperatures and veloci-



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Ingenious Controls Instead of Transformers

The basic principle is this: that you don't need *absolutely continuous power* for high reliability, but rather *speedy restoration of service* after disturbances do occur. So instead of providing for expensive extra transformer capacity, they developed a control system that automatically and rapidly clears trouble. And a power loss up to four seconds doesn't slow down the plant.

Devastating Tornado Didn't Stop Operation

The results of this sound planning were soon evident. Nine months after installation, a devastating tornado hit Lima and knocked out one of the two power lines serving the plant. The two key motors (catalytic cracker blower drive) were thrown out of synchronization. But both were immediately restarted by the ingenious control system. Then a second fault knocked them out again and one motor restarted to keep the process going all through the disturbances.

Disturbances are Cleared Automatically

In the first nine months of operation, there were 12 disturbances which affected these key blower motors. On ten occasions, the controls automatically restarted the motors. The other two times, the motors were restarted manually. Numerous other disturbances have failed to affect plant operation in *any* way.

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To keep the costs down, they built very little spare capacity into the system. Thus if there is a momentary outage, the load must be reapplied in segments. The operation is controlled by Westinghouse high-voltage switchgear, shown at left.

The big power users are the blower motors. If power outage occurs, they're automatically taken off the line by a clever "under-frequency" relay so that the rest of the plant can start up when the fault is cleared. Then in less than one minute, one of the blower motors restarts automatically. The plant keeps operating through the disturbance.

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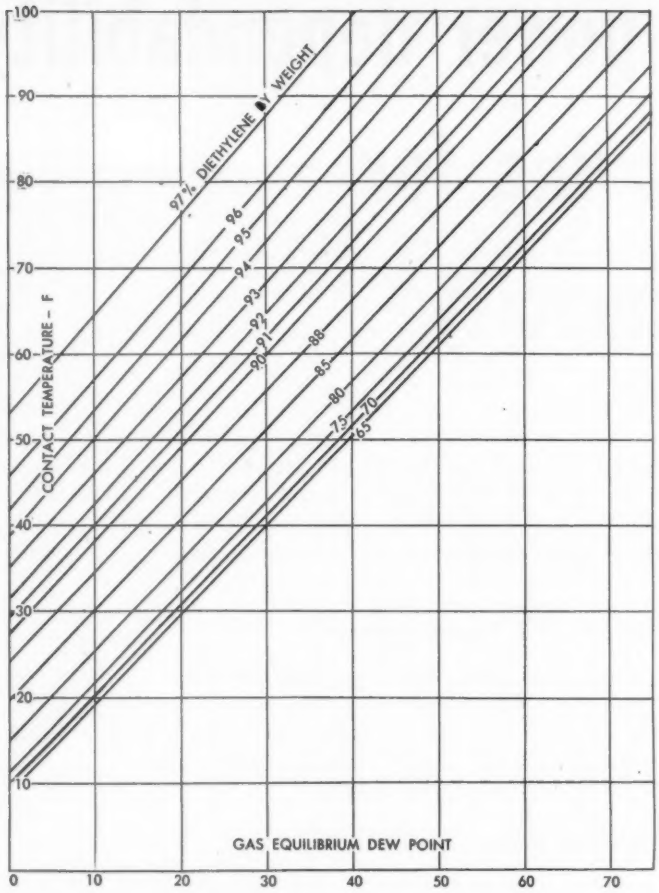
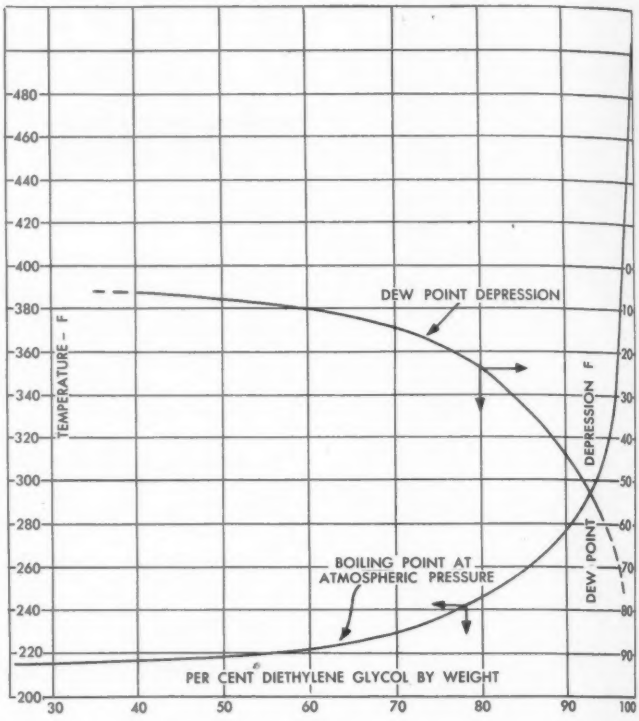


FIG. 3. EQUILIBRIUM dew points vs contact temperature for diethylene glycol-water solutions.

FIG. 4. BOILING point temperature and dew point depression vs per cent diethylene glycol by weight.



ties which yield much lower dew points than those required for hydrate inhibition. Not only is this type of operation more costly from a fuel standpoint, but corrosion, glycol contamination and losses, and downtime are all increased.

The first step in dew point control is to determine the minimum temperatures to which the lines being served by the dehydration plant will be subjected. This depends upon whether the lines are on the surface and subjected to ambient temperatures, or if they are buried and subjected to minimum ground temperatures. These temperatures, of course, vary seasonally and the operation of the dehydration plant should coincide with them.

Once these temperatures have been determined, refer to Fig. 1 and compare them with the hydrate temperature for the particular pressure involved. This will enable the proper selection of dew point depression to be obtained by the plant, allowing at least a five degree approach for plant and temperature variations.

Figs. 3 and 4 are commonly used curves to obtain the proper concentrations of glycol and reboiler temperature for a desired dew point. Fig. 3 enables the operator to select his desired dew point according to his contact temperature by maintaining a given concentration of the glycol to the contactor. Fig. 4 illustrates the proper reboiler temperature required to give the desired glycol concentration. Similar curves are available for tri-ethylene glycol.

A constant circulation rate set at maximum requirements is usually maintained for constant daily loads in that control equipment or attendance cannot be justified because of the small solution requirements.

By close adherence to the above mentioned curves, winter and summer operations can be controlled maintaining minimum temperatures on the equipment and obtaining dew points within a minimum consistant range of the hydrate point.

Equipment and Operation

Most operating problems encountered in the operation of glycol dehydration plants can be related to the contamination of the glycol by foreign material and the breakdown of the glycol at elevated temperatures.

The first place in the system for removal of contaminants is the inlet scrubber. This vessel should be set as close as possible to the contractor. Its function is to remove water, hydrocarbon condensate, crude oil, lubricating oil, and any pipe line dust or dirt which comes along with the gas. This vessel should be of adequate size and maintained in proper working order for if light oils and condensate are carried into the contactor, they eventually find their way to the rectifier where they have a tendency to crush the packing in packed columns, and blow glycol out the top and bottom with a resultant fire hazard. Heavy oils accumulate carbonaceous material in the still and reboiler which eventually finds its way to reservoir section where it must be drained off.

Some oils form an emulsion with the glycol. When this emulsion is recirculated some gasoline is absorbed and makes its way to the rectifier where it is driven off overhead with the water. In several cases fires were started from these gasoline vapors coming into contact with the fire in the reboiler. This can be prevented by carrying the vapors away from the top of the rectifier through a downward sloping line into a remotely located separator having a means of drawing off the water separately from the gasoline.

Some operators have recently incorporated the use of a vent tank immediately downstream of the contactor. One of the functions of the vent tank is to remove oxygen and hydrogen sulfide which enter the glycol stream in the contactor. Both of these contaminants are strong oxidizing agents and highly corrosive when in solution at elevated temperatures. Their removal is accomplished by holding the glycol retention time to about 20 to 30 minutes and lowering the pressure to that required to overcome pressure drop to get the glycol into the rectifier. The vent tank is also used as a decanter tank, recovering hydrocarbon liquids which enter the glycol stream in the contactor.

To insure further cleaning, a filter is usually installed downstream of the vent tank to remove dirt, scale, rust, and reaction materials. This filter is usually of the waste pack or cartridge type which can be removed and cleaned with the plant in operation. One type of filter sometimes used has an element of cloth, fibre glass or cotton in the form of a replaceable sack sur-

rounded by a stainless steel wire mesh. It is located upstream of the motor valve controlling the liquid level in the contactor to prevent gas released due to the pressure drop through the motor valve from nullifying its operation. The filter in this location must be kept clean, as a dirty filter raises the back pressure and the liquid level in the contactor, opening the motor valve wider until the pressure drop is taken across the filter instead of the motor valve, with a resultant bursting of the filter sack. One operator using an anti-foaming agent has had considerable erosion of his filters on diethylene glycol service while on tri-ethylene glycol he is using a standard filter ahead of his pump without any apparent difficulty.

Glycol pumping has offered a variety of problems. Glycols are a difficult liquid to contain and to pump. The liquid continually leaks around packing and soon spreads around the entire pump area if not properly handled. There is also a tendency on the part of inexperienced operators to tighten the packing too tightly. The leak problem can be overcome by providing a drainage trough around the pump leading to central sump from which the glycol can be gathered and returned to the main reservoir.

Pumps generally used are of the reciprocating double-acting piston and single acting plunger types driven by electricity, gas, gas-engine or steam. For small package installations, a gas-driven piston pump is often used. For high pressures and low volume pumping, triplex plunger pumps have proved satisfactory. One operator uses a centrifugal turbine pump with a cast iron impeller for a job requiring high volumes and a low head. The impellers cut out in about two months from combined corrosion and erosion effects. He is now trying a bronze impeller to eliminate this costly nuisance.

Pump packing has been an important problem. Cup type leather packings were used on some of earlier simplex pumps, but these soon gave trouble at slow pumping speeds. Metallic packing with a soft babbit center combined with graphite and mica has proved successful. This is a self lubricating packing which limits the leakage to one or two drops every several minutes.

Pump rods have a comparatively short life in glycol service. Part of this is due to the nature of the service and part due to undue tightening of the packing mentioned above. One operator case-hardens his rods apparently with some success. Others have tried chrome and cadmium plating which have worked well in some cases, but on the whole have not proved too successful. Tests were conducted on porcelainized rods, but they did not hold up. One operator is now trying a porcelainized sleeve made from a porcelain fire tube fitted on a machined metal rod.

Power pumps circulating glycol require the usual maintenance of checking oil level and draining and filling periodically. A non-detergent oil

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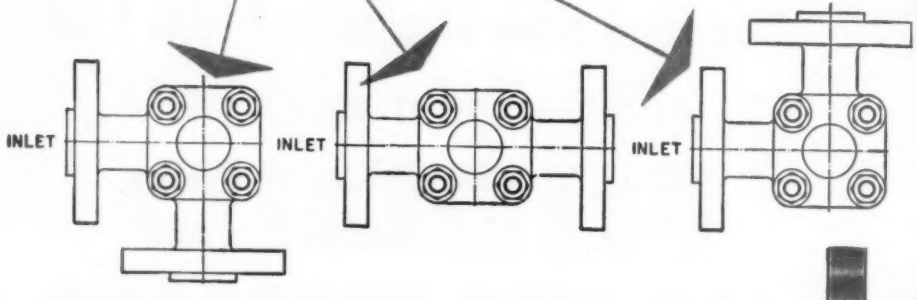

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should be used according to one operator who used a detergent lube oil which reacted with contaminants of the glycol to form a gummy, hard substance that was very difficult to remove. It goes without saying, that a strainer ahead of the pump and a relief valve on the discharge are a must in glycol pumping service.

The reboiler is usually direct-fired or steam-heated. The glycol level is maintained by an overflow pipe to the surge tank or a liquid level controller. With the controller installation the float is normally located in the reboiler and the control valve on the contactor. This introduces a time lag between the opening of the valve and the raising of the level in the reboiler. Failure of the controller or the valve could result in a low liquid level in the reboiler which might burn out a fire tube. The overflow system with the surge tank directly below the reboiler minimizes this hazard by simply insuring the existence of a minimum liquid level.

Where the fuel for the reboiler is not constant or in areas of high winds, the operators usually equip the units with a pump shut-down device in the event of flame failure. This prevents the glycol from circulating with the reboiler out of service which prevents the system from building up with water and minimizes glycol loss to that contained in the contactor.

In windy areas with the problem of the fires being blown out, one operator has relocated the reboiler a safe distance from the main plant, and constructed a six foot sheet metal windbreak completely around the unit with apparent success. Other operators have installed a continuous spark ignition system or a spark igniter to relight the pilot if it goes out.

The surge tanks on some package units have a spiral heat exchanger coil in them for heat transfer from the hot lean glycol in the surge tank to the rich glycol to the rectifier. These coils are difficult to clean and have been known to leak.

The rectifier, operating at the highest temperature in the system, shows the effects of the highest rates of corrosion. Most corrosion occurs below the feed tray and trays above. Very little corrosion occurs in the top or bottom. Also, there seems to be less corrosion with tri-ethylene glycol than with diethylene glycol.

A .1 per cent solution of monoethanolamine is currently being used as a corrosion inhibitor. One operator reports that his rectifier life was approximately two years before he started using monoethanolamine, and that since its use, he has operated over four years with no trouble in sight, although in some cases monoethanolamine has materially increased the corrosion rate.

When monoethanolamine is used with diethylene glycol, a reddish-brown colloidal substance builds up in the system and as the concentration increases, it settles out clogging the system. This material is apparently organic and has some nitrogen in it. It has proved very

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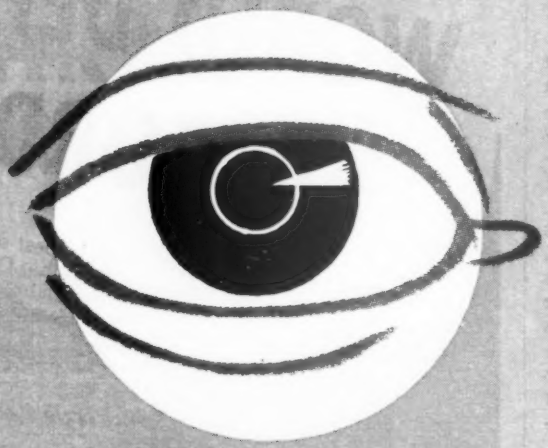

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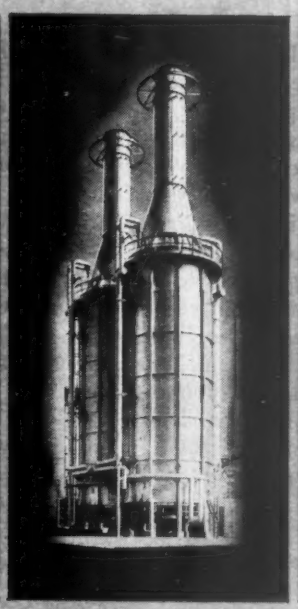

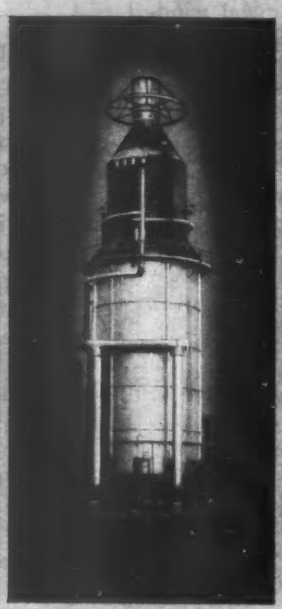

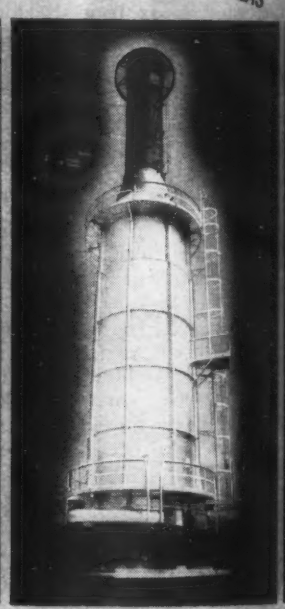

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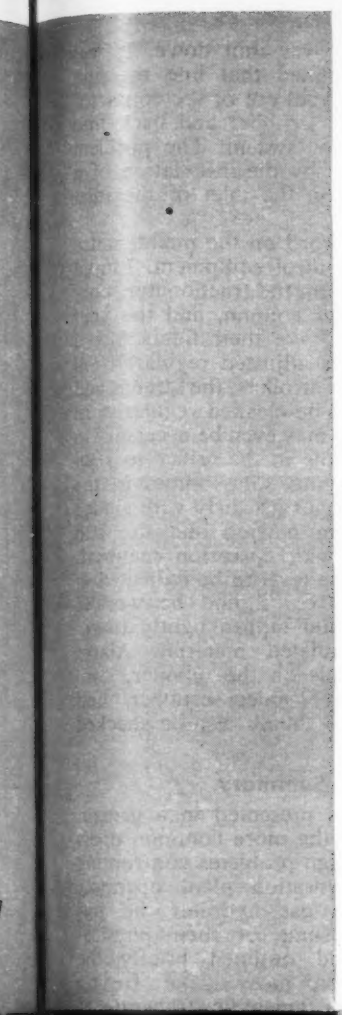

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3. The combustion gases are diverted behind the tubes so that the gases recirculate from the top of the heater downward, behind and between the tubes, thus increasing the heat input to the rear of the heating elements by convection.
4. The recirculated gases also serve to reduce the combustion temperature, reducing the heat intensity at the bottom of the furnace.

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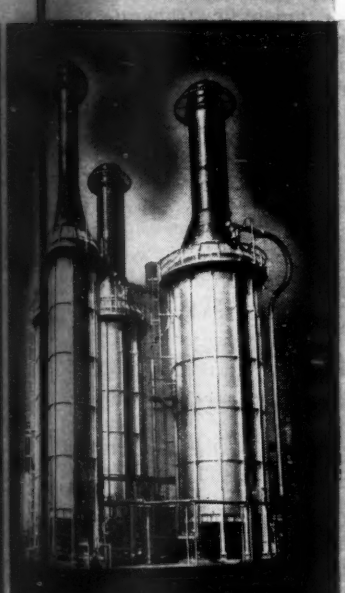

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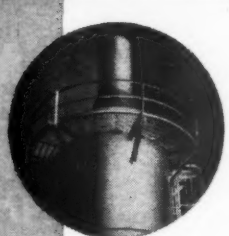

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difficult to filter, eroding conventional filters in a very short time. Some corrosion of the fins in the heat exchanger heating the feed to the rectifier has been experienced by this same operator. One of the newest inhibitors which shows promise is an approximate 1 per cent solution of a complex meta-phosphate which coats the steel parts of the system and inhibits corrosive action.

Rectifier corrosion can be minimized by keeping the system free of contaminants and operating at a minimum temperature as explained elsewhere in this paper. One way to keep the temperature down is to elevate the rectifier to provide the necessary gravity head to return the glycol to storage, and to operate it at atmospheric pressure. Another proposed remedy is to reduce the capacity of the reboiler so that the temperature is raised and lowered quickly which minimizes the time the glycol is at the elevated temperature and subject to decomposition. Some operators have recently gone to stainless steel construction, but on the whole, most designs simply include an ample corrosion allowance.

Another problem frequently encountered in dehydration plant operation is foaming. Glycols foam with hydrocarbon condensate, emulsion, and corrosion products. In many cases, foaming can be caused by lack of experienced operation, as in one case where the unit had been shut down for a time and restarted without draining the condensate from the contactor.

Several anti-foaming agents are available for use as foam breakers. An anti-foaming agent recently used is a higher complex glycol both in the oil soluble and water soluble types. Extremely small concentrations are used on the order of 3 ml per drum. This material has an added advantage in that it is permanent and does not strip out and is added in the same proportion only as glycol is added.

Monoethanolamine is quite often used. Results have been fair but inconclusive. A 1 to 2 per cent solution is constantly added by an extraneous pump as it is stripped in the still.

Glycol losses are a problem consistently facing the dehydration plant operator. Most dehydration equipment is designed to lose less than .1 gallon glycol per million cubic feet treated. This figure generally runs higher because of lack of experience on the part of the operator. Proper start-up and shutting down procedures are very important in order to keep from blowing the glycol out of the system. As mentioned above, recovering glycol from pump packing leaks and returning it to the system saves considerable glycol loss. Some operators even back weld screwed fittings or use socket type fittings to prevent glycol loss. More recently there have been several operators who have installed special semi-continuous distillation units for recovery of contaminated glycol heretofore thrown away.

In one particular plant, a severe glycol loss occured every time the compressor plant was shut down. It was finally determined that line pressure backed the glycol out of the contactor into the inlet scrubber and back into the compressor system. The problem was remedied by the installation of a check valve on the inlet of the inlet scrubber.

One final word on the maintenance of process control equipment. Liquid level controls on the fractionator, contactor, rectifier column, and the vent tank, should have their filters blown and the levels adjusted regularly. On bucket type controllers, the screens and orifice should be cleaned regularly. In some cases, it may even be necessary to enlarge the hole in the orifice to keep it from plugging. Glass tubes in the liquid level gages get dirty with sludge in the bottom portion and the ball checks foul with corrosion materials causing a false level to be indicated in the gage. Valves should be worked periodically and tapped lightly to remove accumulated material. Alarm system controls on the reboiler, contactor, rectifier, inlet scrubber, and solution pump should also be checked periodically.

Summary

Author has presented in a general way some of the more common operating and design problems confronting the gas dehydration plant operator. Starting with gas hydrates, he has pointed out some of their physical properties and outlined briefly the more common methods of freeing frozen lines. A typical flow diagram of a diethylene glycol plant is given. Dew-point determination is discussed, followed by proper dew point control, pointing out the tendency to dehydrate beyond the required range with subsequent deterioration of glycol and equipment. The main portion of the paper is devoted to a discussion of problems directly connected with the plant operation. Methods of keeping the glycol free of contaminants by the use of scrubbers, vent tank and filters are discussed.

Acknowledgment

Grateful acknowledgment is made to the following companies who made available the results of their practical experience in the dehydration of natural gas:

Southern California Gas Company, Southern Counties Gas Company, Black, Sivalls and Bryson, Industrial Engineers, Inc., El Paso Natural Gas, Montana Power Company, Union Oil of California, Hope Natural Gas Company.

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★ ★ ★

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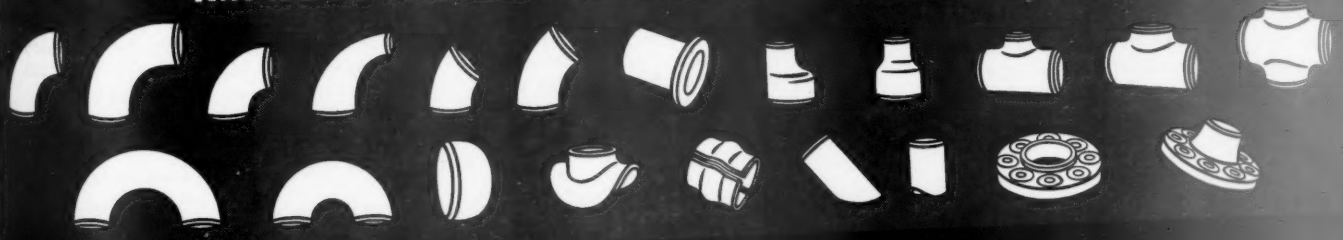

Petroleum Profile

RAYMOND E. LUTON
Vice President Refining Division
Ohio Oil Company

WHAT may be the difference between an oil man and an oilman? It has been said that the first is one saturated thoroughly with oil externally. The oilman has been in the industry all his life, is saturated externally and internally, and probably has some petroleum hydrocarbons coursing through his blood system.

Be that as it may, "Ray" Luton can qualify certainly as an oilman, under that definition. From Harmony, Pennsylvania, fields where his driller-producer father, Charles B., began his oil work, Ray went along toward the west with the family, always in sight of oil fields, always in the "smell" range of crude oil. There are those who say that the metaphysical or psychological effect of the name of his birthplace is reflected in his handling of the far-flung activities of his refining organization at Ohio Oil.

As happens "in our best families" very frequently, Ray got his initiation into oildom as an adult at Indian Refining Company, western Illinois, during vacations from Marietta (Ohio) College, where he wrestled with the intricacies of chemical engineering, then a somewhat "infant" science in the petroleum refining industry. Inducted into and serving during World War I, he came back to manage the laboratory for Export Oil Corporation of Louisiana, decided to find out more about Kentucky crudes as a laboratory specialist with Petroleum Refining at Latonia. At about the tag end of "The Little Depression" (1923) Lincoln Oil Refining needed a chemist who could pinch-hit as assistant superintendent, or vice versa and hired Ray, at Robinson, Illinois, and when next year Lincoln joined Ohio Oil Company, he just naturally went along.

Lincoln was operated under its original name until 1935, with Ray Luton as vice president and general superintendent of that works. Dropping the old company name, he became general superintendent of refineries for the parent company. The history following appears to have been inevitable; handling a difficult job to make it look easy, he was retitled manager of the refining division, 1947, to lead with more authority and responsibility the expansion program of the refining facilities. With the election recently of C. Z. Hardwick as Ohio Oil's executive vice president and the need for a reassembly of company executives, Ray Luton was elevated to the refining division's vice presidency, and assumed the Pilot's Seat.

A brief and inadequate resume of Luton the oilman. From all these multitudinous duties he shoves back from his desk, reaches into a corner for a fly rod; a fowling piece; a surf casting rig or, a rifle-gun and in the same motion takes off with the same smooth action he applies to his day's work. It may be the limitless reaches of Wyoming's antelope, deer, or elk country, to match wits with game there, where "half the world stands on end, and the other half stands on t'other". He may run away to Canada's fishing waters; 'tis said he slings a mean plug at bass or trout or salmon.

At the slightest arm-twisting, even that self-induced, he is charged with losing himself in the wild goose's haunts, there to make like an inanimate shock of wheat or corn, almost invariably returning with the permitted bag of honkers. Albeit he is credited by those in the know with the capabilities of a trencherman, as efficient and as affable in the carving and the consumption as in the procuring stages of the wildfowler's pastimes. And of all these activities much more may be said without repetition.

On his home range he allies himself with several cooperative groups. He is a member of the API general committee on refining, a director of Western Petroleum Refiners Association, the two leading trade organizations in his field. In 1933 he aided in reorganizing the Second National Bank in Robinson, Illinois, and still serves as its vice president. He is a Scottish Rite Mason, and a Shriner.

And most indicative of his alive, forward-looking attitude, he attended the Advanced Management Program at Harvard University, in 1951.

And so is Luton, the man.

About the Crude Oil Purchase Order

The order that "no pipe line company purchasing or transporting less than the amount fixed by the order shall be allowed to purchase or transport oil in Oklahoma," issued by the Oklahoma Corporation Commission, has commanded shocked attention from the crude oil purchasing and transmission branches of the industry.

Ostensibly the order was designed to supersede the previously accepted practice of "pipe line proration." Under this practice when the pipe line company found the purchase of all the oil produced by its connected wells would be in excess of the amount that it could transport or store, or when the purchasing companies found the connected capacity (or allowable) in excess of their requirements, the ratio between the volume desired and the volume available would be translated into a percentage figure. If supply were 10 per cent above the amount needed, a 10 per cent cut was applied to the allowable on each connected well.

Known as "taking ratably," the procedure was accepted by custom and was required by state law in Oklahoma and many other states. It would appear that such a custom, established over the years and seemingly fair to all, would be continued. The new order changes this method. The Commission decrees that all legally produced oil will be purchased, whether or not the purchaser requires it.

The legality of the order is questionable. Can a company be forced by decree, legislation, or any other device, to purchase and pay for a product it cannot sell or otherwise profitably dispose of and which presents the storage problems that are characteristic of crude oil? Obviously, an operating company would hesitate to test the order by violating it, because to do so would jeopardize its future right to do business in the state. Further, the Connally "Hot Oil" Act gives Federal stature to any violation of state proration orders. Violation of this decree would then place the offending pipe line in jeopardy of Federal charges. The result of these factors has been to force universal compliance with the order thus far.

Aside from the question of legality, the injustice of the order is clear. The Commission is armed with one of the earliest state market demand statutes and requires purchasing companies to provide it with crude purchase nominations. That it consistently sets allowable higher than the requested amounts may be due to inefficient record keeping but it could be remedied by estimates of new wells without timely reporting.

There is little doubt that the domestic crude oil producer is in a potentially precarious position. As General Ernest O. Thompson, Chairman of the Texas Railroad Commission, so aptly phrased it in his recent address before the Independent Petroleum Association of America, "The independent oil producers cannot stand further reductions in runs without serious danger of bankruptcy."

The factors that caused past reduction in runs, and the fear of even greater future reductions, have given rise to the present supply situation. Storage of crude oil and products has long since passed prudent levels and rapidly approaches capacity. This situation is the direct result of a decline in product exports, reduced domestic consumption of certain products, increased imports of crude oil, and an increase in domestic production capacity deemed necessary to national defense.

The cure is to be found in a logical alteration of the contributing factors, not in the precipitate action of any state regulatory body seeking to alter by decree a situation resulting from normal reaction to the natural law of supply and demand.

— *Sim H. Crews.*

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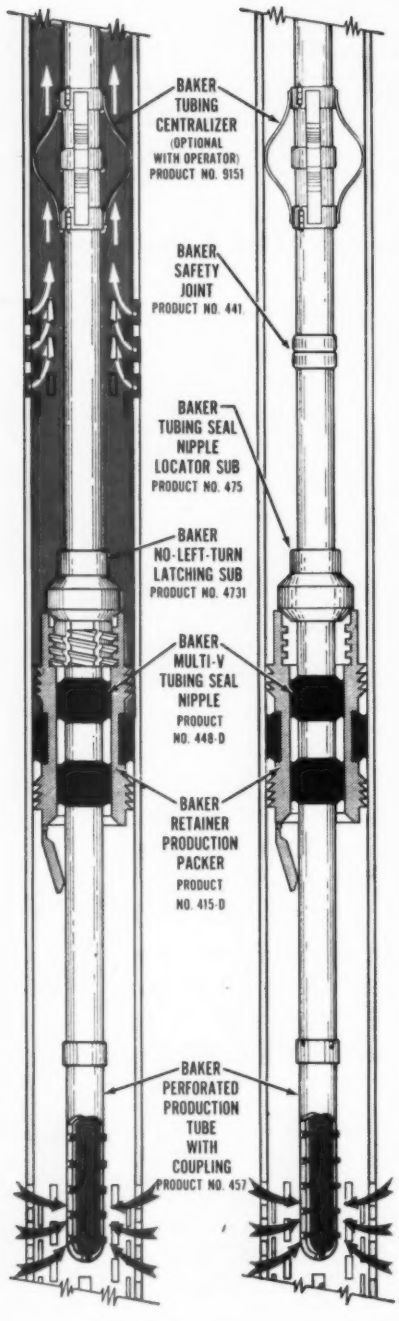
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PACKS-OFF AND HOLDS UNDER HIGH BHT—Baker Retainer Production Packers will hold high pressures under conditions of high temperatures. Hundreds of Baker Packers are in successful service in Southwest and Gulf Coast areas where temperatures in excess of 300 degrees are not uncommon.

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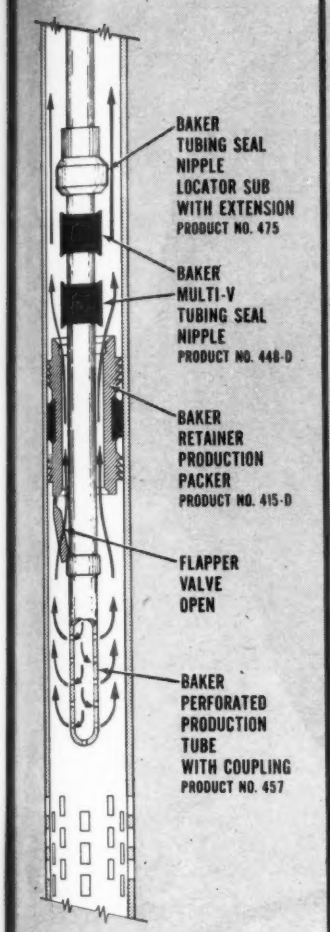
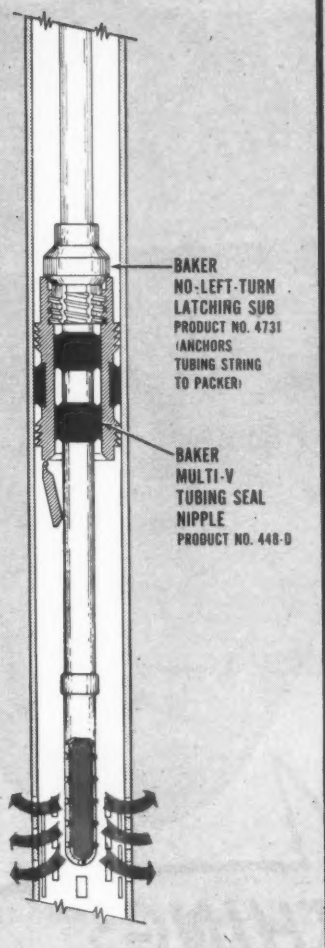
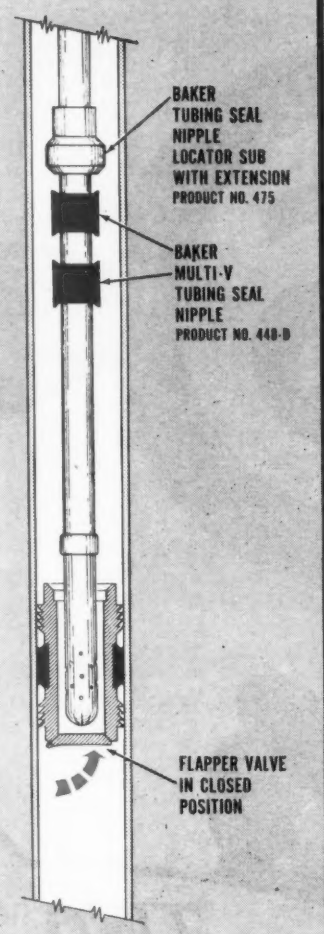


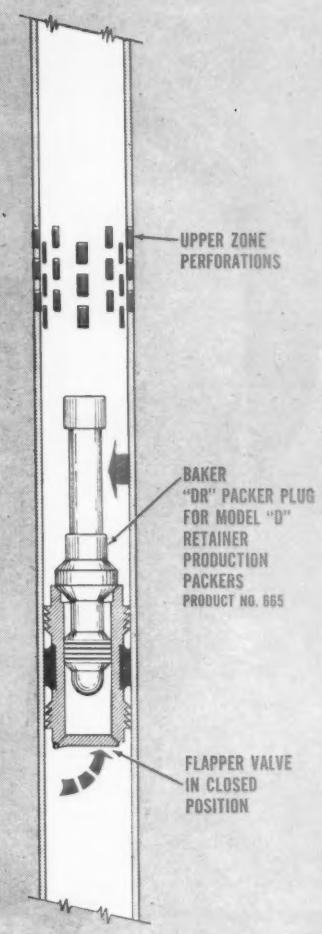
Washing or Circulating Tubing Seal Nipples removed from packer bore. Flapper Valve held open by tubing extending below Tubing Seal Nipples.



Pressuring Below Packer Acid or cement squeeze, formation fracture, gas or water injection. Latch Sub used when squeeze pressures exceed tubing weight.



Isolate Zone Below Packer Tubing String removed, Flapper Valve closed. Isolates pressure differentials (squeeze, productions) from below the packer.



Temporary Bridge Plug For working over zones above packer. DR Plug run in on Baker Retrievable Cementer, and retrieved with overshot. *Permanent Bridge Plug* can be formed with Trip Bob (not illustrated).

RESISTS CORROSION—The cast-iron used in the construction of Baker Packers is far more resistant to corrosion than the casing in which the packer is set, thus making it ideal for permanent installations, or for use in areas plagued with a severe corrosion problem.

EASILY DRILLABLE—The Baker Packer is constructed of drillable cast-iron, and its design supplements the breaking-up action of the bit. Whether it has been in the well for only a few hours, or for ten years, the Baker Packer can be drilled up in minimum time. Expensive and hazardous "milling-out" operations never are required.

IMPORTANT FACTS

Baker Packers are used in a majority of installations where conditions of extreme pressure, temperature, or depth are present. Baker Packers also dominate Dual Zone installations, particularly those involving two-packer, crossed-flow arrangements.

BUT IT IS ALSO TRUE that *more* Baker Packers are used for *simple single zone* completions than for *any other type of completion*, and that *most* Baker Dual Zone installations employ *only one* packer.

Ask any Baker representative, or office, for complete details, as well as your copy of the recent Baker Equipment News dealing with DUAL ZONE COMPLETION PRACTICES. There is no charge, and no obligation, for specific recommendations and completion planning advice available from Baker Technical Advisers. Why not be prepared for your next completion?

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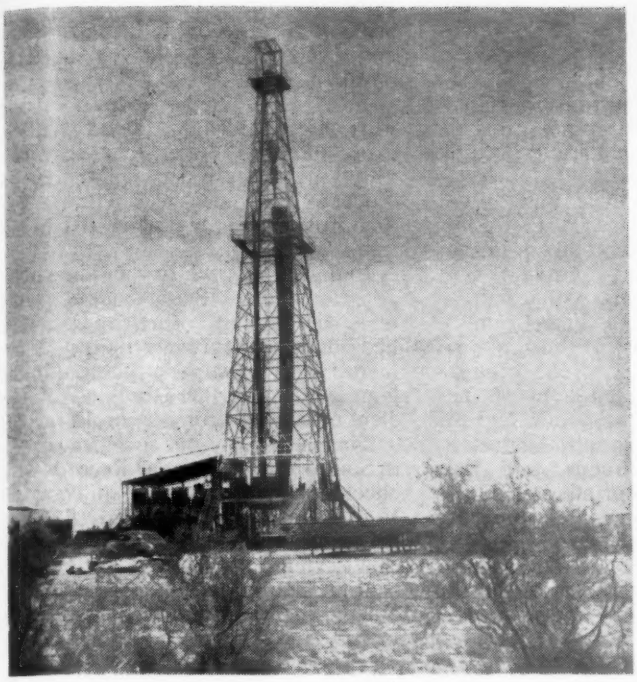
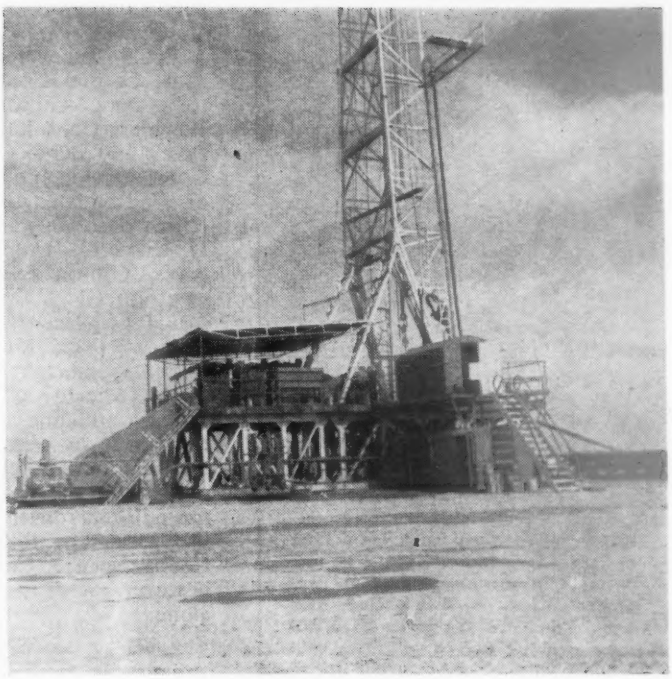


Drilling rig in Indiana.



Deep test in Tri-State Basin.

Technological developments have pushed oil field expansion and secondary recovery programs until

Indiana Has Highest Output in 91 Years

KENNETH G. BOLING

THE first commercial petroleum was produced in Indiana at Crawford County in 1862; just 3 years after the first well was drilled for oil in Pennsylvania. From 1862 to 1888, about 600 wells were drilled for oil and gas in Indiana. From 1889 to 1904 the 3788 wells produced 11,400,000 bbl of oil; Indiana was then the fourth largest producing state. All this production was from the Trenton limestone, on the Cincinnati Arch.

In 1886 gas production in Indiana was valued at $300,000; in 1889, oil production in the state, was 33,375 bbl and was valued at $31,414. In 1952 the total oil production was 11,937,000 bbl. Its dollar value is approximately 1000 times greater than it was at the beginning. Indiana is now the tenth oil state in the nation.

The period of 1920 to 1938 had scattered activity in Gibson, Pike, Knox, and Vanderburgh counties. Publication 42, of the Indiana Department of Conservation, "Oil Fields of Southwestern Indiana," by W. N. Logan, shows that Pike County had the Davidson pool, Glezen pool, (this pool proved productive in 1952) Bowman pool, (now a a part of the Union Bowman pool) Oakland City pool, Oatsville pool, Arthur pool, Alford gas pool, Petersburg gas pool, (discovered in 1897, and ultimately producing oil in 1953). Gibson county had the Francisco pool, discovered in 1922 and redeveloped and extended in 1939 and 1949. The Princeton pools, East and West, were discovered in 1903, and are now under active water flood, 1952-1953; the Union pool, which is now a part of Union Bowman pool, an area still actively being drilled. Knox County had the Monroe City pool, discovered in 1903, and extended in 1941, 1950, and 1951.

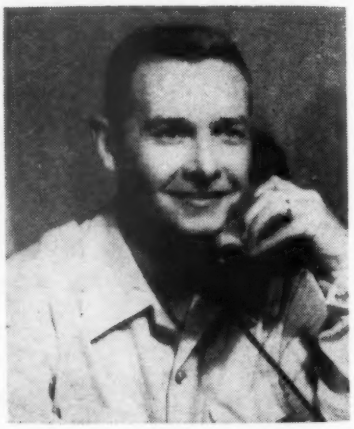
This period, 1920-1938, had many discoveries large and small, yet there was no conscientious effort to develop or extend the oil field operations. Hampered by low prices, poor rigs, little exploration know-how; the oil business dawdled along until 1938.

The Illinois discoveries in 1937 and 1938, by the Pure Oil Company: the No. 1 Bunny Travis 33 3N8E Clay County, Illinois, and the No. 1 Bradley 1 26 1N7E Wayne County, Illinois, had a staggering effect on the oil industry. Major companies sent in staffs of geologists and geophysicists and the "boom" was on, in both Indiana and Illinois. Indiana's gusher was the Griffin pool discovery. The Granville Hays, Ed Amis, Dan Boone, W. D. Allen et al, No. 1 Cooper Estate 13 3S14W Gibson County, Indiana, which came in on December 15, 1938, made 3000 bbl per day to open the Griffin pool.

The Griffin pool, on the Wabash River anticline, produces from 9 pays: Mansfield at 1250 ft, Pottsville at 1450

EXCLUSIVE

The Author



Kenneth G. Boling is petroleum geologist, engineer, and managing partner of Boling, Levine, and Yabrove, oil producers of Evansville, Indiana. He was graduated with an AB in geology from Hanover in 1937, joining Pure Oil that same year. He worked with Pure until 1948 in the Tri-State area and Michigan. From 1942 to 1945 he was an aerial phototopographer with the U. S. Army Engineers. From 1948 to 1950 Boling served as assistant manager of land and geological department for S. D. Jarvis.

ft, Degonia at 1750 ft, Waltersburg at 2100 ft, Tar Springs sand at 2190 ft, Cypress sand at 2550 ft, Bethel at 2700 ft, Aux Vases at 2800 ft, and the McCloskey at 2890 ft, (any porous, oolitic limestone zone, producing oil in the Ste. Genevieve formation). This field has 599 producing wells, 16 dry holes, and 10 abandoned wells. To January 1, 1953, it has produced 32,877,741 bbl and approximately 3000 bbl per day. There is now an active water flood of the Cypress sandstone and of the Biehl sand (Pennsylvania) in operation in the Griffin pool.†

Development Is Technological

Indiana's oil business is geared to the technological developments in the oil industry as a whole; and its discovery rate follows roughly the trends in exploration and production practices, developed elsewhere, and gradually imported to the state.

The seismograph phase of the early part of the present play indicates this trend. Those with asterisk before them in the list below were seismograph discoveries:

Pools discovered in 1938 were: *Griffin Consolidated pool, Gibson, Posey County; *Heusler Dome pool, Posey County; Millersburg pool, Warrick County.

Pools discovered in 1939, were: Rockport pool, Spencer County, and Francisco pool east, Gibson County.

Pools discovered in 1940, were: St. Thomas pool, Knox County; *Caborn Consolidated, and Mumford Hills pools, Posey County; Grandview and Hatfield pools, Spencer County; *Owensville Consolidated pool, Gibson County; Fleener pool, Gibson County.

Pools discovered in 1941, were: *Mt. Carmel Consolidated pool, Patoka pool, Gibson County; Union, Bowman Consolidated pool, Gibson, Pike, and Knox counties; *College Consolidated, *La Motte, *Mt. Vernon Consolidated, Rapture, and *Welborn Consolidated pools, Posey County; Kirksville, Columbia, and Johnson pools, Gibson County; Vaughn and *Vernon Heights pools, Vanderburgh County; Spurgeon pool, Pike County; Glendale pool, Daviess County.

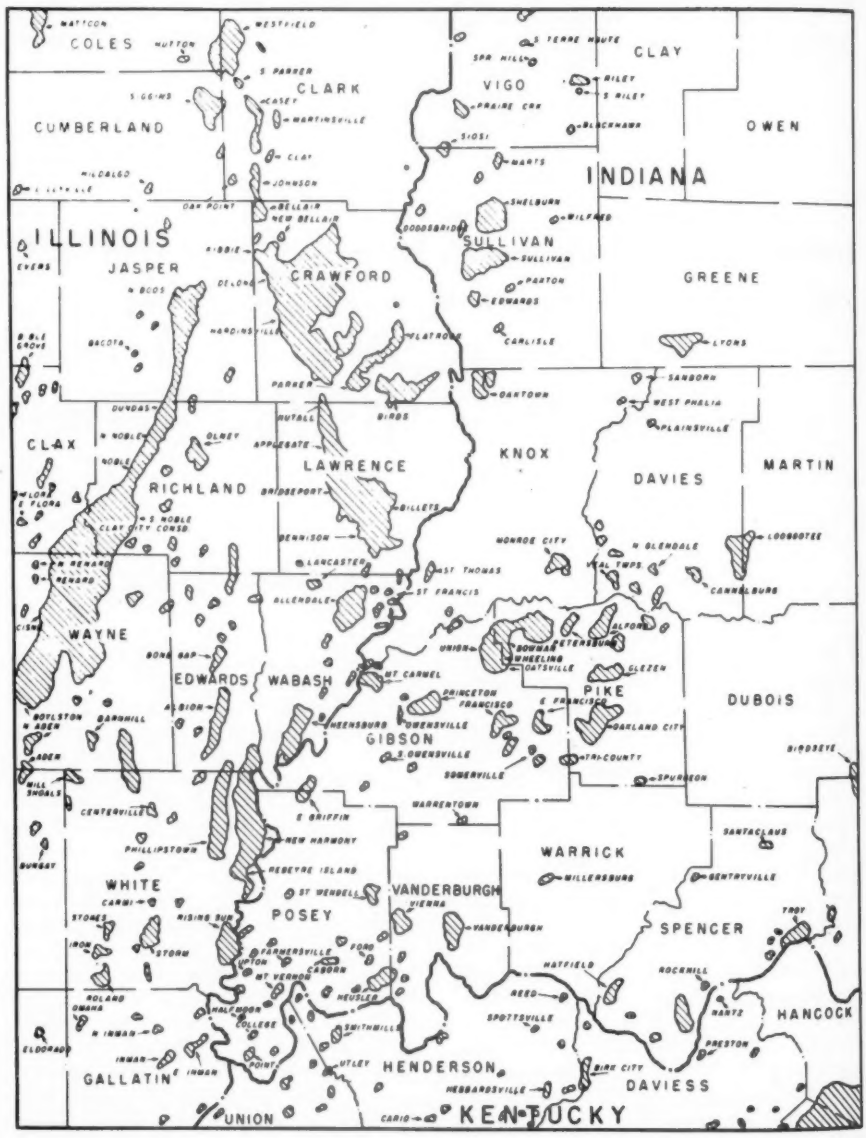
Developments from 1938 through 1941, indicate the tracing-out of the Wabash anticline to the South, and to the North, by seismograph: The picking-up of parallel trends, and the checking-out by subsurface, accounts for adjacent development in some of this area. The Pike County Warrick County Spencer County developments, however, were mostly by the drill alone.

The war years, 1942-1945 were lean years, with a declining rate of discovery; 1945 to 1947, showed increased development.

In May, 1947, the Leduc reef field was discovered. In January, 1948, came the Red Water reef field, followed by the Golden Spike reef, in August of the same year. These Canadian reefs were big news to the oil industry.

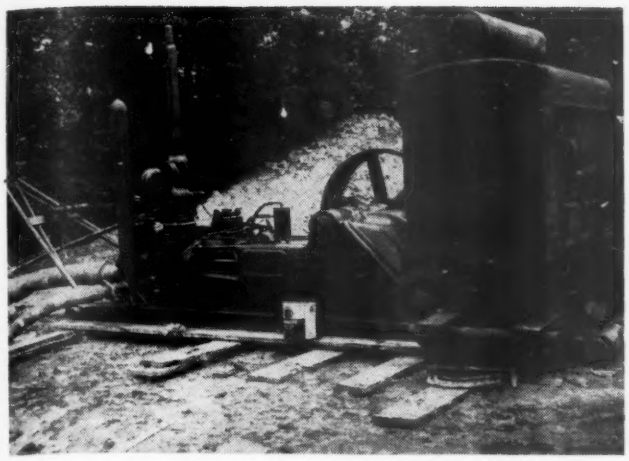
Indiana's oil industry became reef-conscious; for Indiana had Niagaran reefs; (in 1927, Cumings and Schrock had shown conclusively that, "the numerous quaquaversal structures in the Niagaran in Northern Indiana are ancient coral and stromatoporoid reefs"!)

Therefore, why not subsurface reefs in Southwestern Indiana? Records were checked; the Siosi pool, Sullivan and Vigo counties discovered in 1926 and producing from the Devonian, was of small extent, (1000 acres) but from 37 wells, it had produced 3,596,380 bbl of oil to January 1, 1949. It had 107 ft



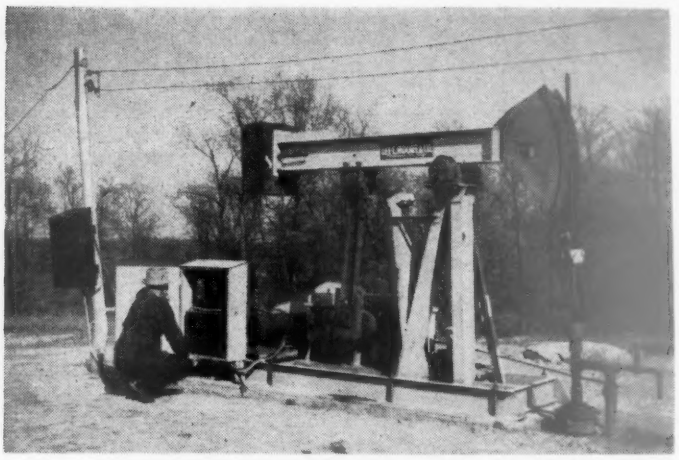
Compiled by K. G. Boling.

Pools of Southwestern Indiana and adjacent areas of the Tri-State Basin.



—T. Farrand, Sun Oil.

Typical mud pump installation.



—T. Farrand, Sun Oil.

Typical electric pumping unit.

of closure on top of the Devonian. Prairie Creek pool, Vigo County, discovered in 1937, producing from the Devonian, (620 acres) had 24 wells, and had accumulated 1,049,909 bbl to January 31, 1949. It had 110 feet of closure on top of the Devonian. This in a country where 25 ft to 50 ft of closure may indicate a productive oil field. Something needed investigation.

Lowenstams' "Marine pool, Madison County, Illinois, Silurian Reef Producer" in the Illinois Geological Survey Report of Inv. No. 131, published in 1948, and his "Niagaran Reefs in Illinois and Their Relation to Oil Accumulation" Report of Inv. No. 145, published in 1949, became required reading for Indiana geologists.

Indiana could now prove producing Niagaran reefs in Sullivan and Vigo counties. Again the "boom" was on; flying magnetometers, gravity surveys, seismograph surveys, subsurface and coal studies, became the order of the day.

Sullivan County had 8 eight new pool discoveries from 1949 to 1950. Vigo County had 6 pools discovered in the same period.

These counties proved a testing ground for exploration techniques. The flying magnetometer was out, because the results could not be satisfactorily correlated. Gravity survey showed a successful reconnaissance tool at low cost per mile, but unfortunately it did not locate structures precisely. Seismograph reconnaissance shooting on one mile intervals was expensive, and could miss small reef closures, however, seismograph detail on a gravity anomaly, seemed to be the answer to exploration.

The reef play lost emphasis, because of the small extent of the reef structures found; the high water cut of Devonian oil, and the high cost of exploration. Reef pools are cited in Table 1.

Indiana's production from reef type closures is seldom from the reef itself, but in general from the Devonian formation draped over the reef pinnacle and even some production in the Lower Mississippian, Chester, and even Pennsylvanian beds, where the reflected Silurian closure is sufficient to create a structure trap.

Table 1

Reef pool	County	Disc. date	Area, acres	Wells	Accum. prod. to 1-31-52, bbl
Dodds Bridge	Sullivan	1942	440	26	1,247,160
Fairbanks	Sullivan	1950	420	21	886,336
Marts	Sullivan	1949	320	23	1,466,362
Wilfred	Sullivan	1948	320	17	174,072
Blackhawk	Vigo	1949	300	15	251,457
Riley	Vigo	1949	100	5	10,945
Riley South	Vigo	1952	140	7	35,103
Springhill	Vigo	1948	350	26	436,773
Terra Haute E.	Vigo	1951	300	15	358,530
Terra Haute S.	Vigo	1949	200	14	148,598

The years 1951 and 1952 indicated much activity among the independent oil companies and the independent geologists. "Hickey" (anticline) hunting, had given way to the search for stratigraphic traps. In 1951 22 discovery wells were brought in, only 3 of which seem to warrant a summary.

Terra Haute E is described in the reef discussion in this paper.

Monroe City new pool, Knox County, discovered in 1951, 390 acres, 25 wells, made 78,606 bbl to January 31, 1952. This, plus the production of Monroe City, North, discovered in 1950, where 300 acres and 30 wells had made 393,716 bbl to January 31, 1952: and, Monroe City, West, discovered in 1950, 610 acres, 61 wells; made an accumulated 586,550 bbl for this pool. This all adds up to a fair oil pool. If consolidated, we have a total of 1300 acres, and 116 producing wells, which made 988,872 bbl of oil in about two years. The geology of the Monroe City pool is simply a south plunging anticline of low structural relief, which has a series of stratigraphic traps along its flanks.

Caborn South pool, discovered in 1951, has 110 acres, 11 wells, and has made 79,782 bbl to January 31, 1952. The geology of this pool is that of an anticline faulted out to the east and south, with the accumulation being on the up-thrown side of the fault, with production limited to lenticular sands, trapped out against the anticlinal flank.

Although 1952 was not a banner year, 17 new discoveries were drilled, but only one seems to warrant a description here. Glezen, Pike County, discovered in 1952, 150 acres, 15 wells, produced from the Bethel sand flowing 78,642 bbl. More surprising, this pool was a "doodle bug" discovery; even though it was mapped by C. A. Malott and P. B. Stockdale in 1919, and that map published as Fig. CXLV, page 960, Handbook of Indiana Geology, published in 1922.

In 1953 3 discoveries of some merit were found. The Petersburg discovery, (map was published originally in "Handbook of Indiana Geology," Fig. CXL11, page 957, mapped by Malott and Stockdale, in 1919.) The Petersburg structure had produced gas on top of the structure. The discovery well made 132 bbl in 24 hr through ½ in. choke from the Bethel sand, 1312-18 ft. The second pool discovery, was the Huntingburg pool, in Dubois County where the No. 1 Frank Seifert 32, 3S5W flowed from the open hole in the McCloskey limestone, and has an IP of 300 bbl in 24 hr. This is a localized structure, a small dome, with a lenticular porosity section of McCloskey, trapped out against the dome. It is my opinion, that the area of production will be small. The third pool is in the old Troy pool in Spencer County, Indiana. The No. 1 C. A. Busick has a pay in the Salem limestone; this indicates an extension of the zone of Salem production.

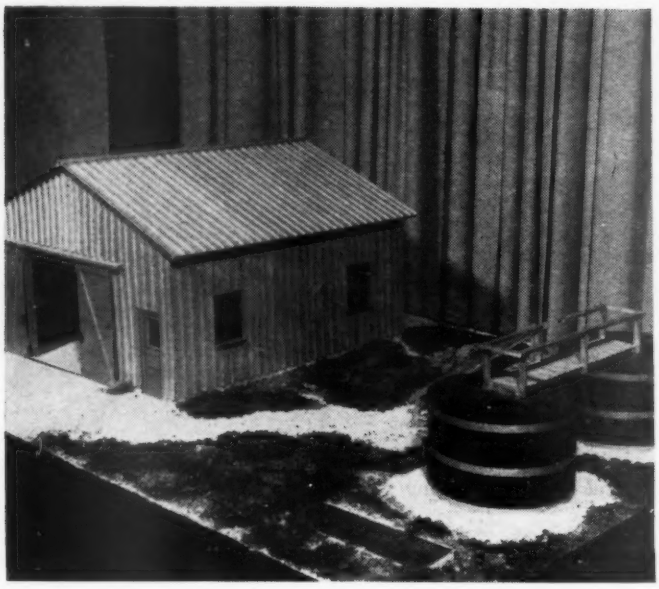
Future Development

Technological know-how can keep up Indiana's production rate. Indiana produced 7 per cent more oil in 1952 than 1951, a total of 11,967,000 bbl.

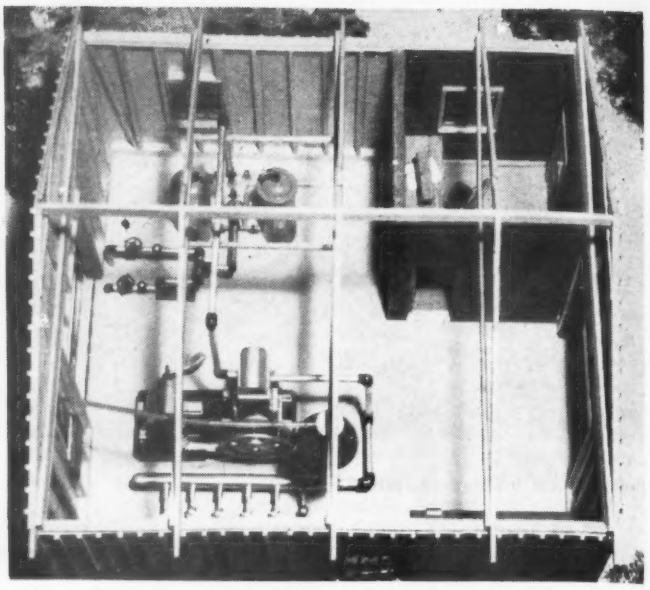
Water-flooding is just now showing effective results with nine floods now in progress in the 8 pools below:

Pool	County	Sand flooded
Caborn	Posey	Penn.
Dodds Bridge	Sullivan	Penn.
Griffin	Posey and Gibson	Penn. – Cypress
Heusler	Posey	Waltersburg
Mt. Vernon	Posey	Cypress
North Owensville	Gibson	Cypress
West Sullivan		Penn.
E. Princeton	Gibson	Penn.

Electric log analysis: The mathe-



Exterior of typical waterflood filter plant.



—*Scale model by B. Walker.*

Interior view of same waterflood filter plant.

matic analysis of electric logs, either by the Hamilton or Schlumberger method; for both normal, lateral, and microlog curves, is not yet in common application. This method, however, has proved better than 85 per cent effective in practical application, where multiple curves are available from old logs.

Hydraulic fracture: The method of fracturing by hydraulic fluids, plus a propping agent, is just now becoming a production tool of wide application. It has a large degree of success. The average sand in Indiana has about 18 to 19 per cent average porosity, as determined from the core, and electric log analysis. The permeability profile is generally somewhat erratic. The multiple sand completions of Indiana, lend themselves to successful hydraulic fracture techniques.

By utilizing the new tools of electric log analysis, and hydraulic fracture, we can now extend the economic limit of pools to include oil reserves heretofore sub-marginal, from an economic angle. Such pool extensions may be completed with little or no risk-factor (dry hole factor) to the operator. In general, the application of these tools, can hold Indiana's production at a status quo for a considerable length of time.

Exploration by methods other than subsurface, has declined rapidly in Indiana. The high cost of exploration techniques, such as seismograph and gravity, have not paid off, because of the lenticularity, and erratic nature of the producing sands that create a pattern of scattered small pools.

There are, however, counties in which production has been found, and which are, from the subsurface standpoint, uncontrolled, that badly need modern exploration methods. For example, Knox, Warrick, Spencer, Dubois, Daviess, and Green. These counties will ultimately produce oil, but from pools as yet undiscovered.

Knox has several good pools and a lot of unexplored area; Green, Daviess, and Spencer have Salem oil, at a shallow depth.

Little is known of the deep formations. One well in the Griffin pool has tested the St. Peter sand. Superior's No. 17 H. C. Ford, in White County, Illinois, TD 7682 ft was plugged back to the Salem limestone. The writer cannot, at the present time, advocate, deep drilling in Indiana, because of limited subsurface information.

Costs for drilling and completion prices in Indiana, are in line with Illinois. The average price per foot drilled, is $3.75 for pool wells and $4 to $4.50 for wildcat wells. Mud clauses are common below the St. Louis limestone. Completion costs are variable, but average, approximately $7.50 per foot. Land expense is variable, due to "oil wise" farmers involved. Wildcat acreage is in general, $1 to $5 per acre; acreage near production, $5 to $25 per acre. To drill and equip a first well on a lease costs approximately $12.50 to $15 per foot.

Profits: A successful operator seldom sets pipe on less than 10 ft of productive sand. Average primary recovery figures run from 100 bbl to 300 bbl per acre foot, for producing sands, and multiple pays are common. The average well has a primary reserve of between 20,000 bbl and 40,000 bbl of oil, and secondary, in floodable sands, of a like amount. The average depth per well is 1780 ft. The posted price of oil is $3.02. Operational cost and taxes seldom exceed $1 per barrel.

There is no proration. On the basis of decline curves typical of gas expansion drive pools, in Illinois, a profit of approximately $20,000 to $40,000 per producing well may be anticipated by operators who make completions on sound technological data.

Geology of Indiana

The main structural features of Indiana, include an anticlinal area, separating two synclinal areas. The northwestern arm (Kankakee Arch) of the Cincinnati Arch, forms the anticlinal area and crosses Indiana from Dearborn County on the southeast to Lake County on the northwest.

The synclinal area of southwestern Indiana is a portion of the Illinois basin or Eastern Interior Basin. The Illinois, Indiana, Kentucky Basin, was part of a basin that included the Michigan, in pre-Devonian time, but from then on the two basins sank separately leaving the Kankakee Arch. The La Salle anticlinal belt, formed chiefly during the Pennsylvanian period, divided the pre-Pennsylvania, Illinois, Kentucky Basin into two parts; the larger, and western, of which, is generally known as the Illinois Basin.

The first deformation took place in post-Chester, pre-Pennsylvania time, with further deformation continuing progressively southward during the Pennsylvanian.

The synclinal area of Northeastern Indiana is the southern end of the Michigan Basin, where it is restricted by the Kankakee Arch and the Findlay Arch.

This paper will be concerned with the Illinois Basin, Eastern Interior Basin, Illinois, Indiana, and Kentucky Basin, and most commonly known as the Tri-State Basin.

MAJOR STRUCTURAL FEATURES

The Duquoin, Centralia Monocline, Salem, Louden anticline, Clay City anticline, La Salle anticlinal belt, and the Wabash River anticline, are the major structural features of the Illinois Basin.

Associated with the Wabash River anticline are two fault systems; the New Harmony, Indiana, to the east,

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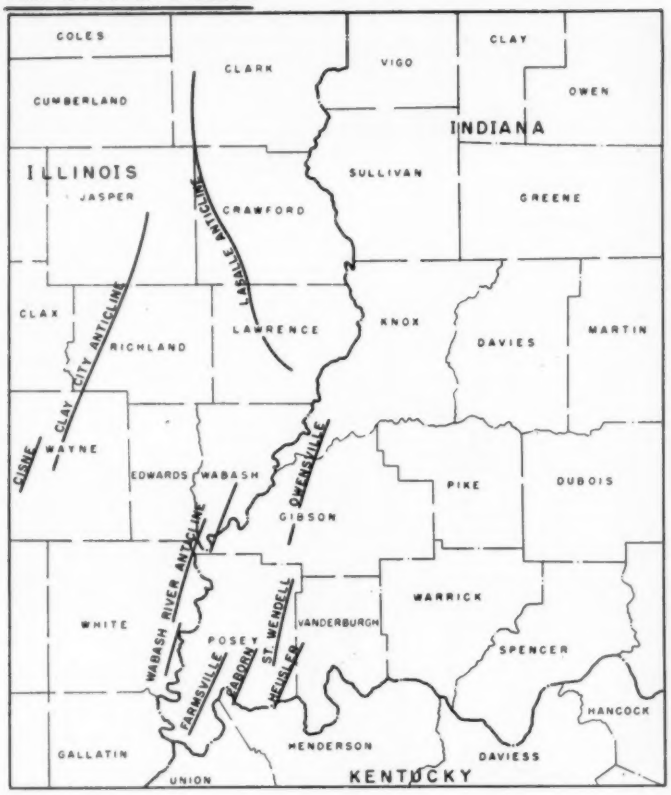
TRI-STATE AREA



Structure areas of the Tri-State Basin.

—*T. Farrand, Sun Oil.*

Typical drawworks unit.

and the Phillipstown, Illinois, system to the west. Two other fault systems are involved, the Brownsville, Illinois, fault, west of Carmi, and the major Shawneetown Rough Creek fault of Kentucky.

Indiana geological structure is effected by the La Salle anticlinal belt. It is a row of anticlines arranged en echelon, and it extends 200 miles from northcentral, to southeastern Illinois. Southwest of St. Francisville, Illinois, it is intersected and lost in the Wabash River anticlinal system. The Wabash River anticline is situated in the graben formed between the Phillipstown and the New Harmony faults. The Wabash River anticlinal system sets the pattern for the anticlinal system of southwestern Indiana. Its south southwest trend is in evidence in the smaller anticlinal features and their accompanying faults, such as, Farmersville, Bufkin, Caborn, Owensville, and the St. Wendells, St. Phillips, structures:

STRATIGRAPHY

Certain differences in nomenclature are in evidence between the Indiana and Illinois columnar sections. These have been disregarded, to a great extent, by the petroleum geologist working from Illinois, into Indiana, with Illinois nomenclature being generally accepted. In this article, the Illinois nomenclature is used.

Pennsylvanian System

Made up of Conemaugh, Allegany, and Pottsville series the Pennsylvanian System is comprised of the Wabash, (Merom) Millersburg, Petersburg, Stanton Brazil, and the Mansfield formation. It is, in general, a series of sandstones of a lenticular nature, interbedded in black, carbonaceous shales and thin coal beds. This system approximates about 1600 ft of section in Posey County, Indiana, thinning to the north to 800 ft in Sullivan and Vigo counties, also thinning to the east where in Dubois County only 300 ft of section is present.

Mississippian System — Chester Series

Kinkaid Limestone: Type locality at Kinkaid Creek, Jackson County, Illinois. Named by Weller 1920. Limestone and shale; interval 20 ft to 35 ft thick; when not cut out by Pennsylvania limestone 2 ft to 15 ft thick; displays typical, undulating bedding planes on weather surface. It contains Spirifer (increbescens) and Chactates.

Degonia Sandstone: Type locality at Degonia Township Randolph County, Illinois. Named by Weller 1920. Sandstone, fine grained, hard, often quartizitic, forms waterfalls; ranges in thickness from 10 ft to 35 ft.

Clore Limestone: Type locality at Clore School, Randolph County, Illinois. Named by Weller 1913. Interval between Palestine sandstone and Degonia sandstone; mostly shale, with thin, yellow, impure limestones. Ranges in thickness from 20 ft to 45 ft. Contains Bastostomella (nitidula) Clore index Fossil in Illinois.

Palestine Sandstone: Type locality, Palestine Township, Randolph County, Illinois. Named by Weller 1913. Sandstone, fine grained, hard, often quartizitic. Ranges in thickness from 5 ft to 30 ft.

Menard Limestone: Type locality at Menard, Randolph County, Illinois. Named by Weller in 1913. Interval between Waltersburg sandstone, and Palestine sandstone. Shale with shaley limestone and one fossiliferous limestone. Limestone of 2 ft to 20 ft thick. Interval ranges in thickness from 40 ft to 65 ft. Abundant Allorisma. Subsurface observation indicates these beds to have, locally, 100 ft to 125 ft of thickness, with three distinct limestone beds; the Upper, a dark grey to brown, shaley limestone, approximately 10 ft to 20 ft thick. The Middle, or Massive Menard, 50 ft to 70 ft of dark grey, mottled, dense, to crystalline limestone; often carries blue-grey chert. The Lower (little) Menard, is a grey, very fossiliferous limestone, contains an abundance of brachopod spines.

Waltersburg Sandstone: Type locality at Waltersburg, Pope County, Illinois. Named by Weller 1920. Sandstone, hard, resistant to weathering. Not readily recognizable in the southern two-thirds of Perry County. Ranges in thickness from 0 to 25 ft.

Vienna Limestone: Type locality at Vienna, Johnson County, Illinois. Named by Weller 1920. Interval between the Tar Springs sandstone and Waltersburg sandstone. Variable shale, with thin, sandy bed, and thin limestone, shale, dark to olive green, limestone weathers yellow. Ranges in thickness from 40 ft to 60 ft. Locally, in subsurface, in Knox County, Indiana, this bed is a 20 ft limestone, light brown, oolitic, and resembling the Glen Dean.

Tar Springs Sandstone: Type locality at Tar Springs, Breckinridge County, Kentucky. Named by Owen 1856.

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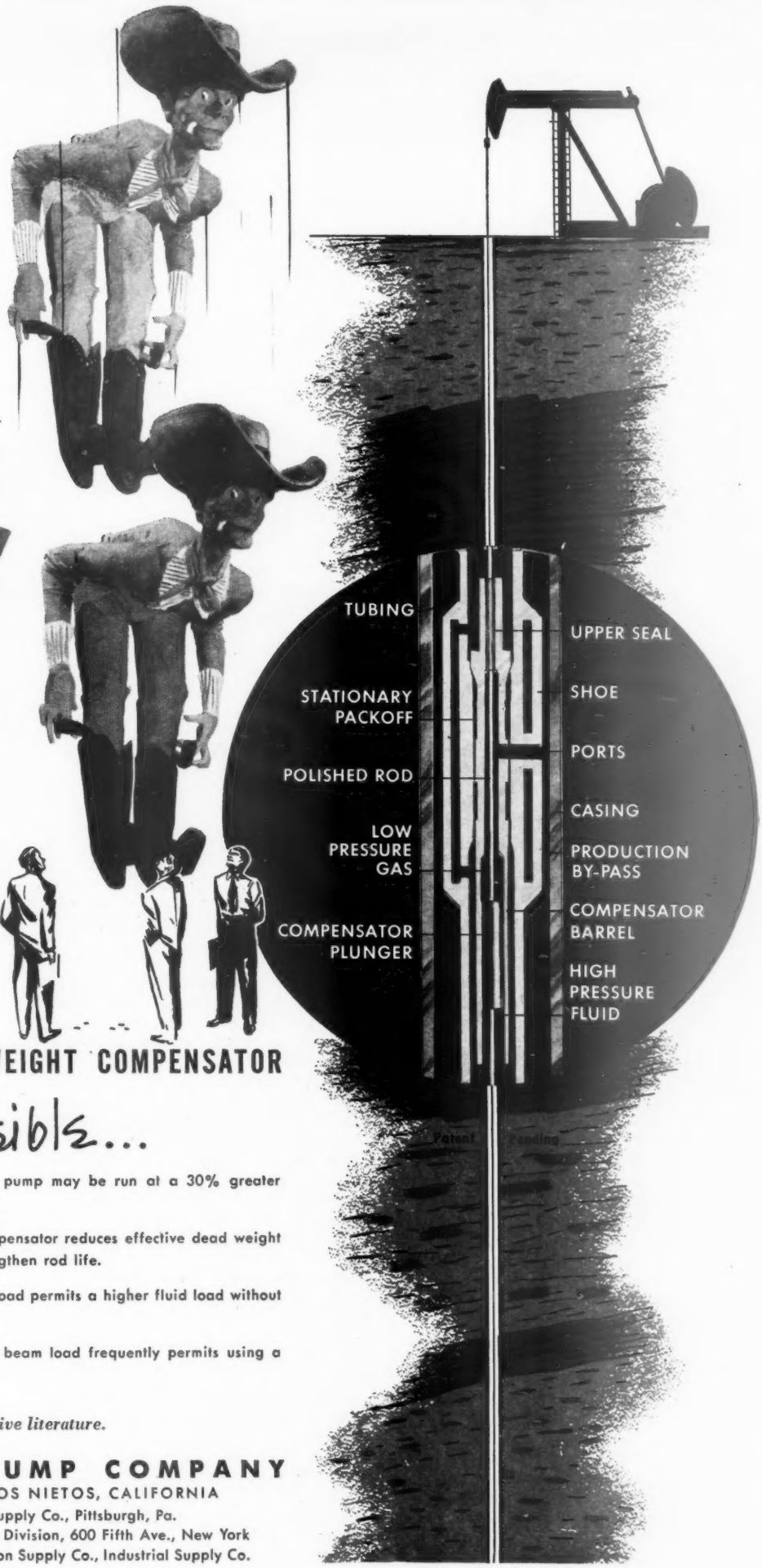

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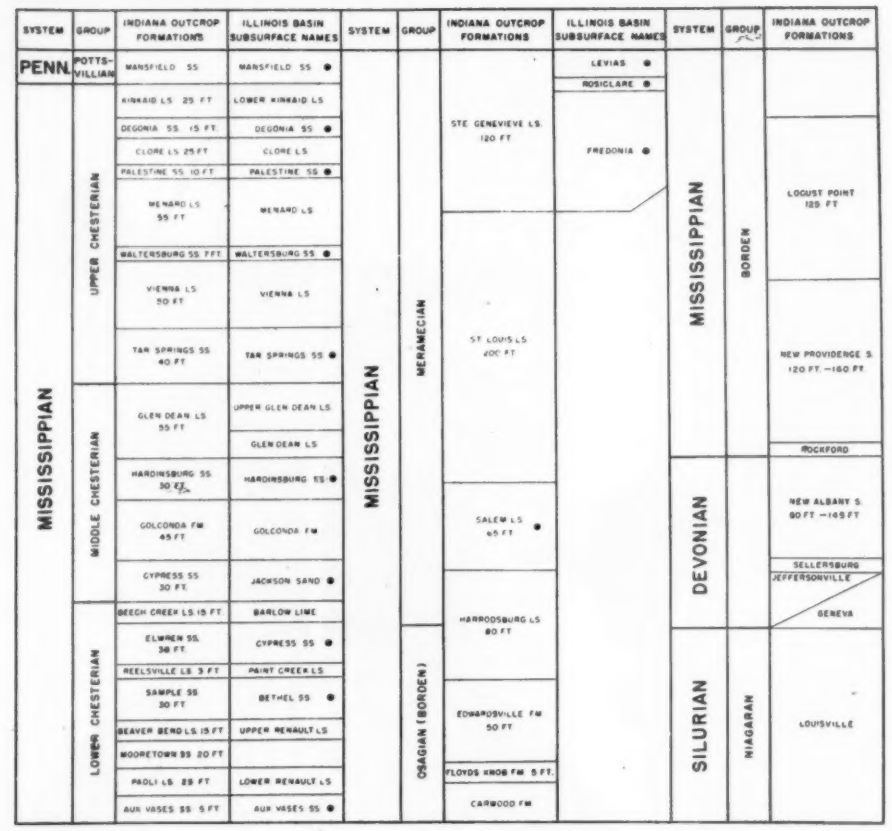

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FROM INDIANA GEOLOGICAL FIELD CONFERENCE GUIDE BOOK 1948

GENERALIZED STRATAGRAPHIC SECTION.
Indiana outcrop and Illinois Basin names.

Massive, characteristically cross-bedded sandstone, and limestone. Ranges in thickness from 0 to 90 ft.

Glen Dean Limestone: Type locality at Glen Dean, Breckinridge County, Kentucky. Named by Butts 1918. Massive, cream colored, oolitic, limestone. Sometimes relatively thin, grey dense beds, intercalated with oolitic bed, 10 ft to 35 ft of fossiliferous shale and thin limestone beds, above massive limestone. Total thickness ranges from 35 ft to 60 ft Pentremites (spicatus) in massive limestone.

Hardinsburg Sandstone: Type locality, Hardinsburg, Breckinridge County, Kentucky. Named by Brokaw 1916. Sandstone and shale; sandstone, flaggy and ripple marked, occasionally massive and cross-bedded. Ranges in thickness from 25 ft to 45 ft.

Golconda Formation: Type locality at Golconda, Pope County, Illinois. Named by Brokaw 1916. Limestone and shale; limestone coarse; encrinoidal, often oolitic, broken by a thin shale bed, 20 ft of olive shale, below limestone. Ranges in thickness from 40 ft to 50 ft. Contains: Pterotocrinus plates, Pentremites, and many Archimedes.

The Jackson sandstone (of Illinois) Cypress sandstone of Indiana; (by the USGS Lexicon of Geologic Names). A subsurface sand of the Mississippi Age in Western Kentucky and Hart County, Illinois, that has been identified as Cypress sand of the Chester group. This little feller is a problem child. Illinois State Survey places the Jackson sand in the lower part of the Golconda section, above the basal Golconda limestone. The Jackson sand in Indiana is a fine grained, calcareous, characteristically laminated sand, containing nodular shale; 10 ft to 40 ft thick.

Barlow Limestone of Illinois, Beechcreek of Indiana; Beechcreek Limestone: Type locality, Beechcreek, Eastern Green County, Indiana. Named by Malott 1919. Distinctive, hard, grey, semi-crystalline limestone; weathers into ragged cubical blocks, displaying large crinoid stems. Ranges in thickness from 8 ft to 30 ft. Contains: Martina contracta, Pentremites godina. The Barlow limestone. The basal Golconda limestone, is distinctive in subsurface; dark grey, to brown, to mottled, dense, to fine crystalline, argillaceous limestone. Ranges from 6 ft to 14 ft. A Marker Bed. (Dr. Swann of the Illinois Geological Survey, and McFarland of the Kentucky Survey, held a field conference at Elizabethtown, Kentucky, September 1, 2, 3, 1953, on this Golconda problem.)

Cypress Sandstone: Elwren Sandstone of Indiana: Type locality at Cypress Creek, Union County, Illinois. Named by Engleman 1868. Calcareous, lite grey to white, very fine, to fine grained, friable, with a thin shaley to silty zone, at the top, in most of its section. The thickness of the Cypress sandstone ranges from 20 ft to 60 ft. In subsurface, however, thicknesses of 140 ft or more, are attained in an area near the oilfield in Clay, Richland, and Wayne counties, Illinois. Malott named the Elwren sandstone in 1919. Type locality, Elwren Station, Monroe County, Indiana, described as sandstone, medium, to fine grained, and characteristically ripple marked: shale, blue grey to olive green, ranges in thickness from 25 ft to 50 ft. Dr. Malott was contemptuous of the petroleum geologist's electric log correlation that tied the Elwren to the Cypress of Illinois; however, time and correlation, have effected an agreement of the State Surveys to the point that the Illinois Columnar section is all but officially employed.

Paint Creek Limestone of Illinois; Reelsville Limestone of Indiana: Type locality at Reelsville, Putman County, Indiana. Named by Malott 1919. Thin, compact, oolitic to suboolitic limestone, containing considerable pyrite, which causes a characteristic red color, in weathered out-crop. Ranges in thickness from 0 to 10 ft Endothyra, Pentremities, and Talarocrinus. The Paint Creek formation consists of alternating, varicolored shales and limestones, with some sandstone beds. The limestones are variable, in color being light to dark grey and brown with some pink to red. In texture, they range from lithographic, to coarsely crinoidal, and they are, more or less, agrillaceous, sandy, oolitic, and fossilferous.

Bethel Sandstone of Illinois; Sample Sandstone of Indiana: Type locality at Sample Station, Breckinridge County, Kentucky. Named by Butts 1918. Sandstone and shale; sandstone prominent in places, shale, and sandy shale in other places. Ranges in thickness from 25 ft to 30 ft. The Bethel sand, locally called the Benoist, is white to grey and light green, and very fine, to fine grained, having parting here and there, and containing flakes of carbonaceous material, and a little mica.

Renault Formation of Illinois: Contains Indiana Beaver Bend Limestone: Type locality at the Big Bend of Beaver Creek near Huron, Lawrence County, Indiana. Named by Malott 1919. Highly oolitic, white, often massive, conspicuously jointed. Ranges in thickness from 2 ft to 20 ft. Abundant productus elegans, and occasional Talarocrinus.

Mooretown Sandstone: Type locality at Mooretown, Lawrence County, Indiana. Named by Cumings 1922. Sandstone or shale or both. Sandstone, fine to medium grained, cross-bedded; shale, soft grey to blue. One or two, thin coal or smut streaks, common in shale. Ranges in thickness from 5 ft to 30 ft. Casts of Lepidopendron and Stigmaria carbonica, below coal seam in top of sandstone.

Paoli Limestone (The Lower Renault of Illinois): Type locality at Paoli, Orange County, Indiana. Named by Elrod 1899. Compact, oolitic, limestone, dark grey to nearly white, sometimes broken by thin calcareous, grey shale beds. Ranges in thickness from 0 to 38 ft. Very fosiliferous in places. Index fossils, Spirifer leidei and Com-

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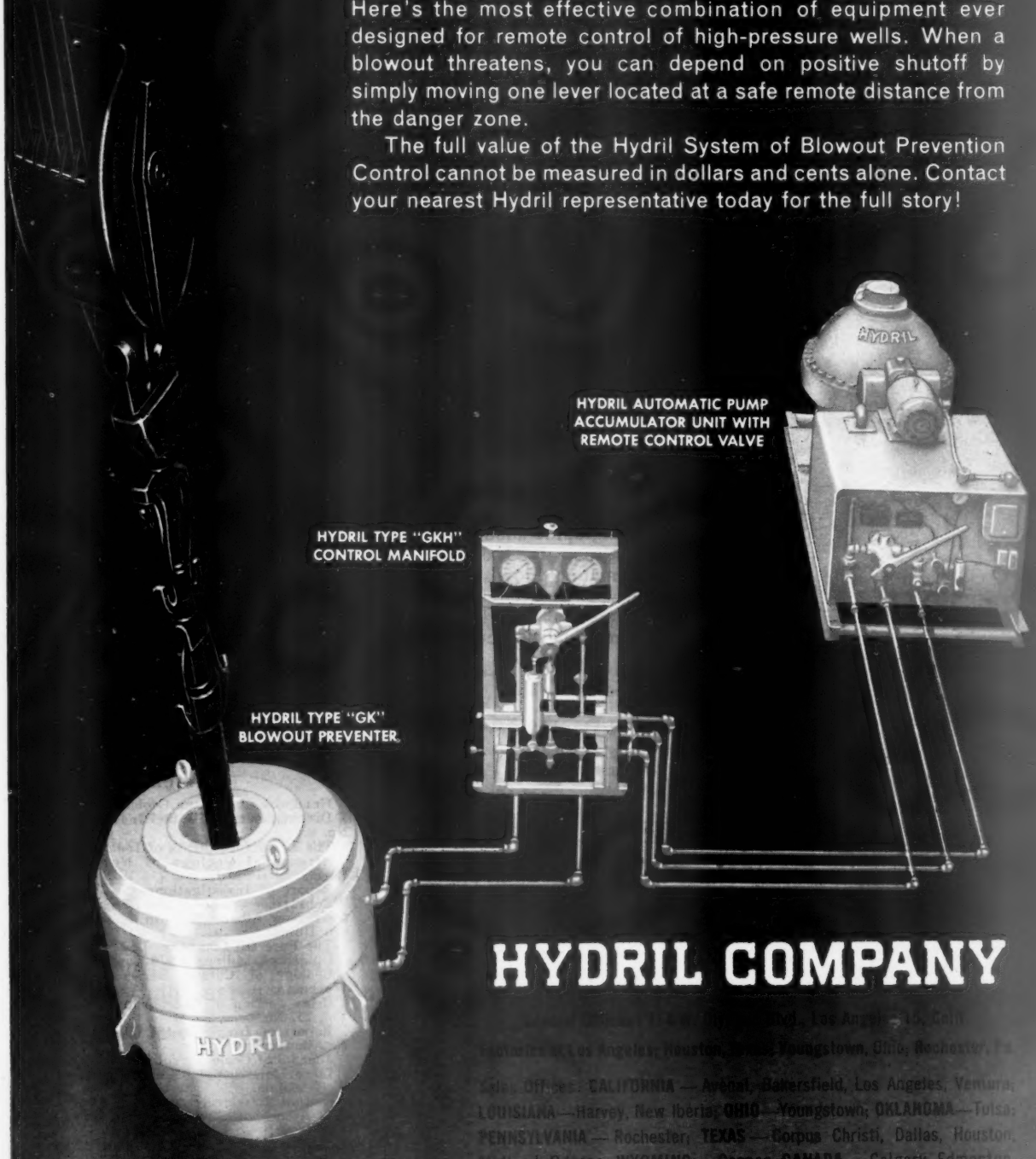
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posita trinucula. The Renault formation is composed of a wide variety of sediments. Where it is thickest, in the deepest part of the basin, it consists mostly of limestone, with minor amounts of interbedded shale, and a few thin beds of sandstone. Where it is thinner, the formation becomes increasingly shaley and sandy.

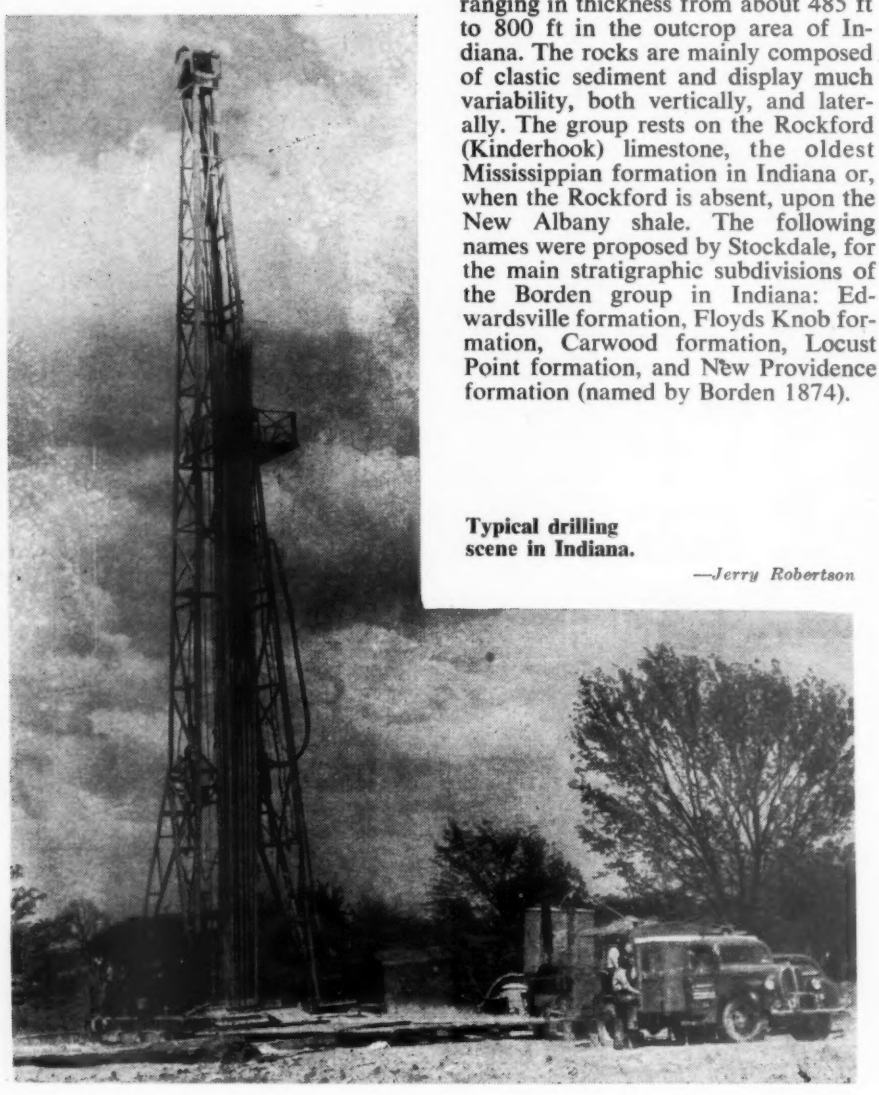
Aux Vases Sandstone of Illinois and Indiana: Type locality along the Aux Vases River, Ste. Genevieve County, Missouri. Named by Keys 1892. Usually a calcareous sandstone, occasionally some green shale. Ranges in thickness from 0 to 15 ft. Outcrop, north side of Highway 58, SE¼ 31 6N2W Lawrence County, Indiana. The Aux Vases sandstone is calcareous, very fine, to fine grained, and greenish grey, to grey, to pink. It contains numerous grey, pink, and yellow oolites and hematite is commonly present.

Meramecian Group, St. Genevieve Limestone: Type locality at Ste. Genevieve, Ste. Genevieve County, Missouri. Named by Shumard 1860. Thick to thin bedded lithographic, to crystalline limestone. Oolitic in part, with cross bedding. Color, white to medium grey, scattered chert. The Levias, 30 ft to 60 ft thick, topped by 1 ft to 6 ft of brecciated limestone. The Rosiclaire, 2 ft to 38 ft thick, composed of calcareous sandstone. The Fredonia, 30 ft to 120 ft thick, containing the Lost River Chert zone. Index fossil, Platycrinus pencillus.

St. Louis Limestone: Type locality at St. Louis, Missouri. Named by Engleman 1847. Granular to lithographic limestone, medium grey in color, thin-bedded, hard, compact, breaking with concoidal fracture. Argillaceous material, both in limestone, and as thin, blue-green, grey and black, shale layers, especially in lower beds. Abundant chert and black flint nodules and stringers in middle and upper part of formation. Ranges in thickness from 100 ft to 300 ft. Index fossil, Lithostrotionella castelnaui.

The Salem Limestone: Type locality at Salem, Washington County, Indiana. Named by Cumings 1901. Limestone massive, granular, commonly cross-bedded. Color, grey to bluish-grey, weathering to buff. Well developed oolitic grains (?) Dolomitic, silty, "bastard" stone, sometimes, either above or below building stone, or entire formation. Ranges in thickness from 30 ft to 80 ft. Abundance of Foraminifera and small crinoid stems. Index fossil. Endothyra baileyi.

Borden Group: The Borden is a group of Lower Mississippian strata, ranging in thickness from about 485 ft to 800 ft in the outcrop area of Indiana. The rocks are mainly composed of clastic sediment and display much variability, both vertically, and laterally. The group rests on the Rockford (Kinderhook) limestone, the oldest Mississippian formation in Indiana or, when the Rockford is absent, upon the New Albany shale. The following names were proposed by Stockdale, for the main stratigraphic subdivisions of the Borden group in Indiana: Edwardsville formation, Floyds Knob formation, Carwood formation, Locust Point formation, and New Providence formation (named by Borden 1874).



Typical drilling scene in Indiana.

—Jerry Robertson

The Devonian System

New Albany Shale: Named by Borden 1874. Type locality, New Albany, Floyds County, Indiana. In fresh breaks, brownish to black in color, hard, brittle, in places sheety. The New Albany is characteristically jointed in two directions; ranges in thickness from 80 ft to 145 ft. Abundant conodonts.

Sellersburg Limestone: Named by Kindle 1899. Type locality, Sellersburg, Clark County, Indiana. Composed of two members: the Beechwood limestone, (named by Butts 1914,) is a light grey, to dark blue, hard, massive, coarsely crystalline, limestone, with abundant crinoidal fragments. The Silver Creek limestone, (named by Butts 1914,) is a fine grained, thinly bedded, argillaceous limestone. Ranges in thickness from 6 ft to 20 ft.

Jeffersonville Limestone: Named by Kindle 1899. Type locality, Jeffersonville, Clark County, Indiana. The formation is grey, to bluish-grey, or bluish-brown, crystalline, hard, compact, relatively pure limestone. Ranges in thickness from 4 ft to 33 ft. The Jeffersonville grades laterally into the dolomitic Geneva formation.

Geneva Magnesian Limestone: Named by Collett 1891. Type locality, Geneva, Shelby County, Indiana. The rock here is dark buff, to brownish; soft to hard; fine grained magnesian limestone. The basal portion of the formation is highly dolomitic. In subsurface, this formation is characteristically a dark brown, granular dolomite. Ranges in thickness from 3 ft to 60 ft. Spirifer acuminatus, Stropheodant hemispheria.

Silurian System

Composed of the Louisville limestone formation, Waldren shale formation, Laurel limestone formation, Osgood shale formation, and the Brassfield limestone formation. I shall not elaborate this Silurian system. Robert Meyers of the Pure Oil Company and others, accept the contact of Devonian and Silurian at the Louisville limestone and refer all the reef-bearing material to the Niagaran.

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†Allied article—"Performance of a Cypress Sand Flood," *The Petroleum Engineer*, September 1953, Page B-86. * * *

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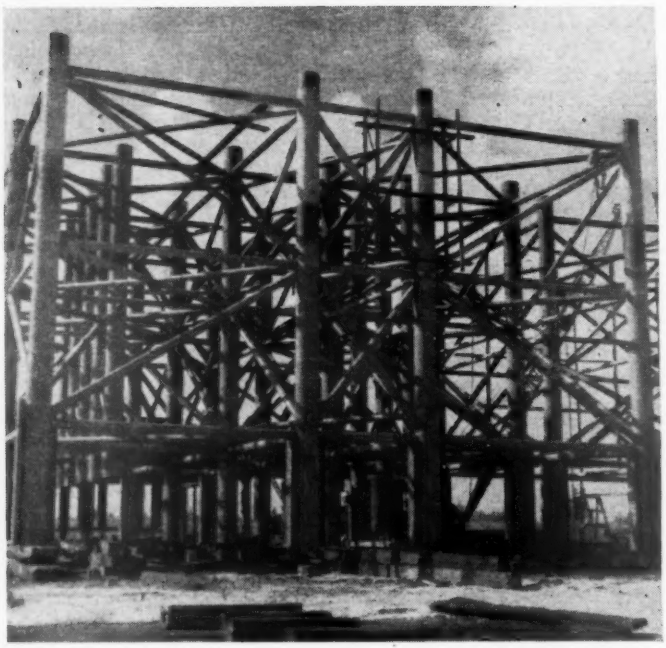
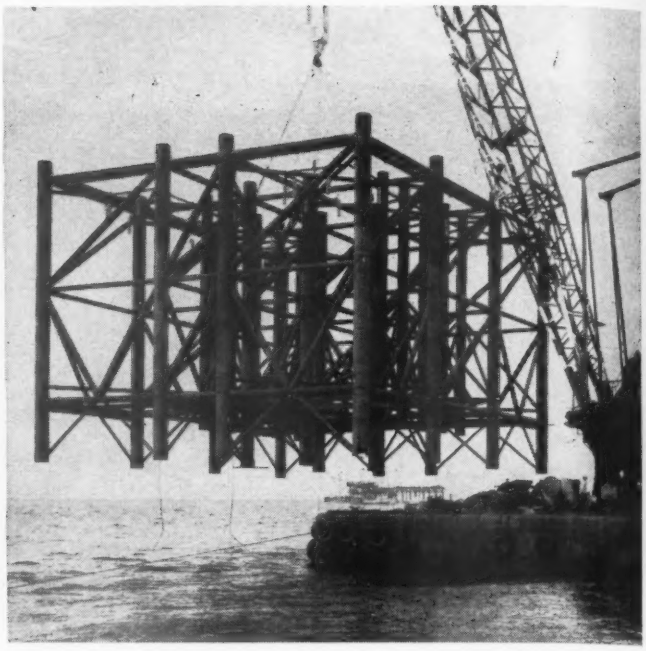


JACKET nearing completion on shore. This one is 60 ft long, 72 ft wide, and 45 ft high. Columns are 26 in. OD pipe. Weight is 150 tons.



SETTING a jacket at sea. This one is 60 by 72 by 59 ft high and weighs 156 tons. Water here is 31 ft deep. This is a multiple (10) well installation.

Structures in the Sea

Wind, waves, and corrosion pose special problems in design of offshore platforms

M. B. WILLEY

IN 1947, after several years of preparation, a number of the major oil companies began an extensive drilling campaign in the open waters of the Gulf of Mexico off Louisiana and Texas. The program then initiated, together with the leasing and exploration activities that preceded it, constitute one of the greatest gambles ever taken by any industry.[1] The extent of this gamble can be appreciated when a look is cast at the early capital expenditures. From 1944 to 1948, some 30 oil companies invested about $100,000,000 in this venture divided into three approximately equal parts for leases, exploration, surveying and allied operations, and drilling. Some of the leases were as far as 35 miles offshore and in water depths up to 65 ft. More than one-quarter billion dollars has been thrown into the Gulf to date, despite the fact that drilling operations have been practically at a standstill for the last three years awaiting a decision of the tidelands squabble.

That this entire operation was indeed a big gamble cannot be denied but upon close scrutiny its size diminishes. In the low, flat Coastal Plain bordering the Gulf are more than 200 known salt domes, each of which is a likely oil prospect as oil production in this area is entirely from sands pierced by these domes. Every salt dome is, therefore, a possible but not an assured, oil field. Of these known domes, approximately one-half have produced oil and a number have yet to be thoroughly tested. The Coastal Plain continues to slope gently beyond the shore line, in places as far as one hundred miles, before the slope steepens and plunges abruptly into the deeps of the Gulf of Mexico. This Continental Shelf, embracing some 129,000 square miles, differs in no way from the Coastal Plain except that it is submerged. That it sheltered a host of salt domes and that a fair percentage of these domes would be productive of oil and gas was a certainty. Consideration then was the finding and producing of oil, known to exist, under new and more difficult conditions than had heretofore been encountered, and the gamble was that these conditions could be surmounted and production obtained at a profit. It was a gamble that the sea, always a formidable antagonist, could be effectively conquered.

In undertaking the design of an offshore structure from which drilling operations could be conducted, the engineer needed the aid of specialists in the fields of oceanography, meteorology,

The Author

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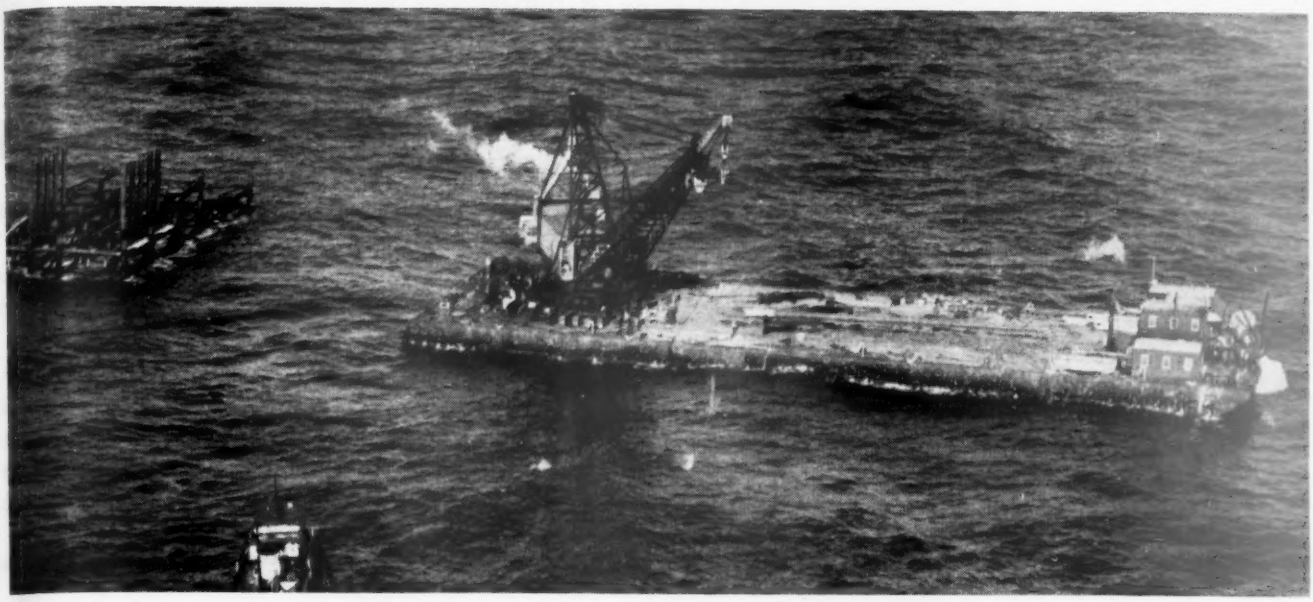
EXCLUSIVE



TWO JACKETS set and some 24 in. OD piles inserted. Derrick ha a 150 ton rated capacity and is mounted on a 90 by 300 by 14 ft barge.

and soil mechanics to outline for him the basic conditions of the problem at each location selected. From the oceanographer he procured information concerning storm tides, maximum wave heights, maximum wave forces, and type of wave to be expected, breaking or non-breaking. The meteorologist supplied data concerning major storms, predicting their direction, frequency, and magnitude. Finally, the expert in the field of soil mechanics contributed, from laboratory analyses of borings taken at the site, his opinions regarding the bearing capacities of piles for various diameters and penetrations whenever possible driving and load tests were used to confirm results obtained by core analysis, and the resistance of the upper soil to shear and compression produced by lateral forces acting upon the driven piles.

Unfortunately for the engineer, nothing factual can be obtained on any of these essential items. This is natural, as these branches of science deal with variables and conditions never identical and so will always remain to ascertain extent inexact. Furthermore, although the past few decades have witnessed a remarkably rapid growth in our knowledge of them, they remain as comparatively new sciences with rapidly changing concept on many essential points. Conditions prevalent during a savage hurricane cannot be simulated in the laboratory and the installation of automatic recording instruments on existing platforms is not only costly but must await the occurrence of a storm at their actual location. So it is natural that the basic conditions governing a particular location as submitted by one specialist will differ, in some respects widely, from those offered by another. Examinations and comparison of the structures that have been erected show that the owners and their engineers have accepted and used conditions at both extremes. Nevertheless, scores of structures were built, upwards of 200 wells drilled, and 26 new oil and gas fields discovered in the Gulf as of January 1, 1951.

For example, opinions regarding the height and force of the maximum waves were and still remain widely divergent. Early assumptions as to maximum wave heights are now known to have been too low. The only losses experienced can be definitely attributed to erroneous conclusions in this regard. The largest loss was experienced at a drilling platform that was in the path of the hurricane that struck the Texas coast October 3, 1949.[2] This structure was situated approximately 6 miles offshore in water having a depth of 47 ft at mean low tide. The decks were at a height of 26 ft above mean water level, an elevation that was expected to provide some clearance between the lowest deck beams and the crest of the maximum waves. Wave crests at least eight feet and possibly as much as fourteen feet higher than expected were experienced during this hurricane. This was evidenced by a careful examination of the damaged structure after the storm. A hurricane having maximum gusts of about 90 miles per hour which struck the New Orleans area early in September 1948 demolished one small structure and badly damaged another. It should be noted, however, that the owner had intended to complete the wells and salvage the structures prior to the hurricane season and had deliberately taken the calculated risk of designing them with a negligible safety factor and insufficient deck elevation above normal water level. Other premanent structures nearby were not damaged by this storm.

Opinions of wave forces as advanced by different oceanographers vary over such a considerable range, as to cast doubt on the safety of some platforms. This is especially true with regard to breaking waves. This confiict will continue to exist until data under actual hurricane conditions are obtained. For the present it will remain necessary to depend upon theoretical considerations and the projection of the deep water wave theory, which is well established, into the doubtful realm of the breaker or shallow water wave.

Unfortunately for the designer, drilling locations are established from the interpretation of subsurface data by geologists and not on the foundation capacity of the soils. Unusually poor foundation material prevails over much of the Gulf Coast Continental Shelf, especially off the coast of Louisiana, where actual point bearing is seldom obtained. An indication of the variable nature of these foundation materials can be obtained from the fact that one company has driven 24-in. diameter tubular piles to penetrations varying from 145 ft to 240 ft to obtain identical load carrying capacity. At one location foundation cores indicated the soil had practically no unconfined compression strength to a penetration of 90 ft. At the other extreme is a location where a thick bed of coarse sand was encountered at 33 ft, and it was impossible to drive piling more than a foot or two into it without jetting.

To complicate further the problem soils must not only carry the vertical loads imposed by drilling operations and by overturning wave forces, but must also carry the lateral loads imposed by wind and waves. Here again we enter a relatively unexplored field and opinions of lateral supporting capacity of soils vary considerably. Two of the major oil companies have undertaken experiments in an attempt to determine the capacity of some of the poorer soils to withstand lateral pressures. These tests consisted of driving

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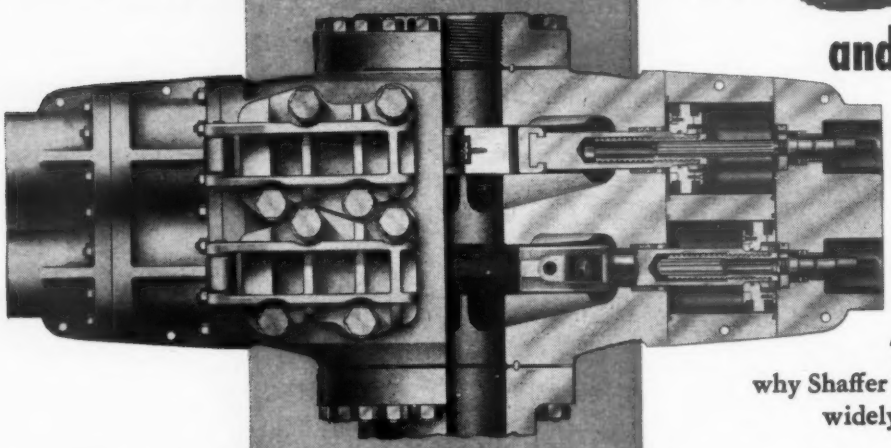

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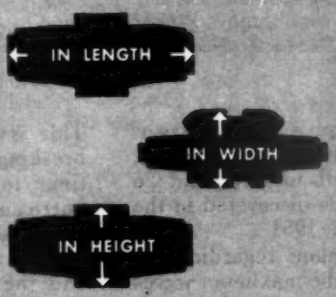

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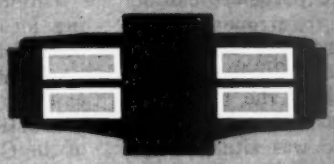

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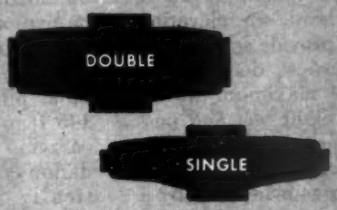

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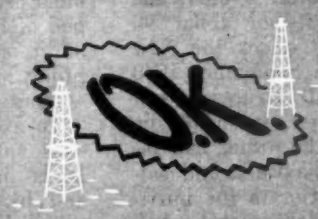

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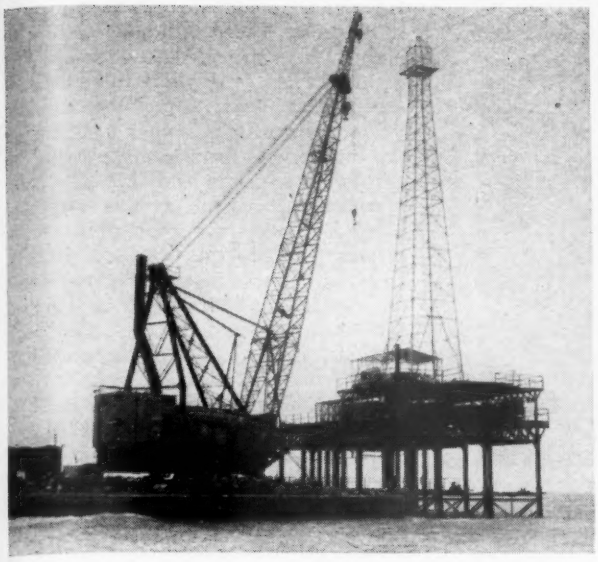
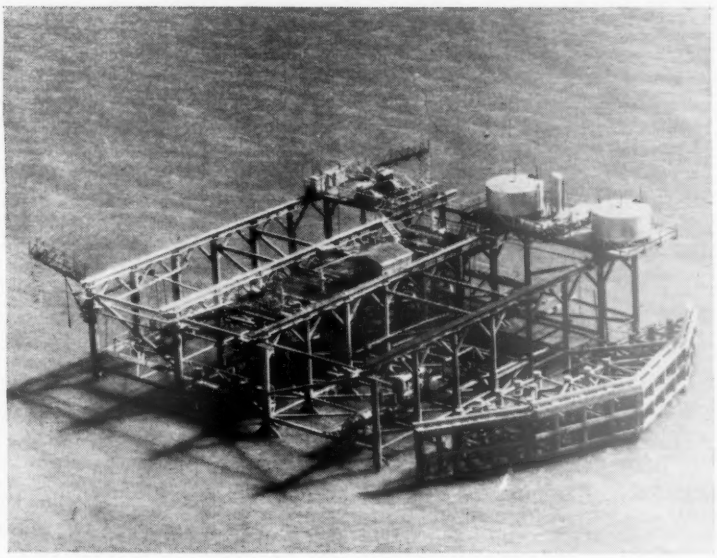


STRUCTURE complete and drilling equipment is being installed.



STRIPPED platform remains for producing operations after drilling is completed.

tubular piles in which had been installed complete systems of strain gages and then jacking against these piles, both (1) steadily and (2) with forces applied periodically to simulate the cycle type loading created by waves. The curves obtained from these tests have been studied and evaluated but the results have not been published. It is reported, however, that they check fairly closely with theoretical assumptions that have been made.[3]

A majority of the offshore structures that have been built are of the jacket type, introduced by the author.[4] Such a structure consists of three integral parts, each of which can be prefabricated onshore into units of sizes and weights limited only by the available erection equipment. In the order in which these units are installed, the first is the jacket or template. This consists of a number of vertical, tubular columns rigidly connected together by transverse and diagonal pipe braces. The height of the jacket and the spacing of the columns is dependent upon the depth of the water, the load conditions and the size and penetration of piling. Each structure consists of whatever number of these jackets are required to provide sufficient space for the drilling operations.

After the jackets have been set side by side on the Gulf floor, prefabricated piling, slightly smaller in diameter than the jacket columns, is inserted therein and driven to the required penetration. When the piles have been driven and cut off to the prescribed height above the level of the water, the third set of units, prefabricated deck sections, are picked up and placed in the proper position on the piles. Upon welding the deck beams or columns to the pile tops the installation is complete and ready for the placing of the drilling equipment. Landings, bumpers and such auxiliary items as may be desired will be incorporated in the complete structure as part of the jackets and deck sections, if possible, or as separate units.

Advantages of this type are:

1. It provides an adequate system of underwater bracing, which is difficult, if not impossible, to otherwise obtain. Without this bracing, especially in deep water and with a very soft, unconsolidated surface stratum, the unsupported length will be so great as to exceed the ability of the column to resist the lateral forces imposed by wind and waves.

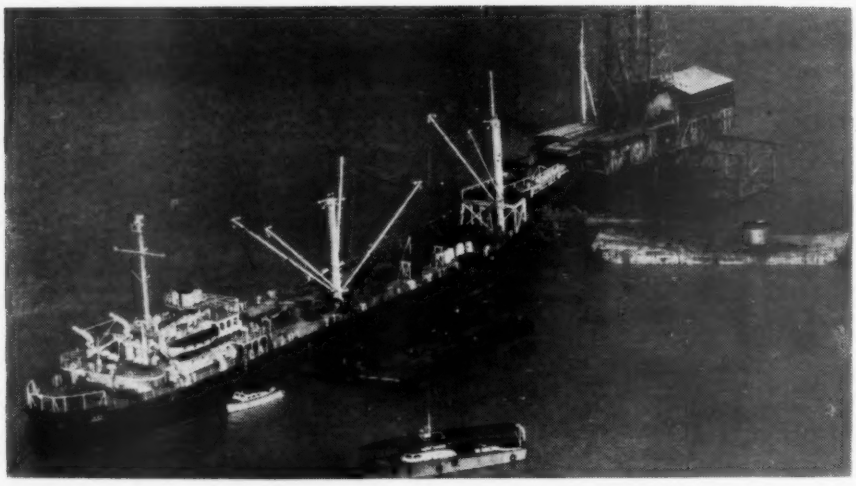
2. As the jackets are prefabricated onshore they can be built to close tolerances. This insures that all the piles which, as previously stated, are driven through the jacket columns, will be vertical and properly spaced. Not only does this eliminate excessive and costly time spent pulling and aligning the piling in the field, but it also permits the prefabrication of decks in large, complete sections onshore.

3. The prefabrication of the structure in large units onshore effects sizable reductions in the time and cost of erection in the Gulf. Offshore construction costs are extremely high because the work is subject to frequent and sometimes lengthy delays due to adverse weather and rough seas and is conducted many miles from the land base with boats and barges the only means of transporting materials, men, and equipment. By appreciably shortening the construction period, as compared to other known or suggested methods, considerable overall economy is effected.

4. Structures are readily salvable and for the same reasons as stated above, the cost is a minimum. Furthermore, the entire structure can be recovered with little or no loss and with nominal expenditure for repairs and renewals.

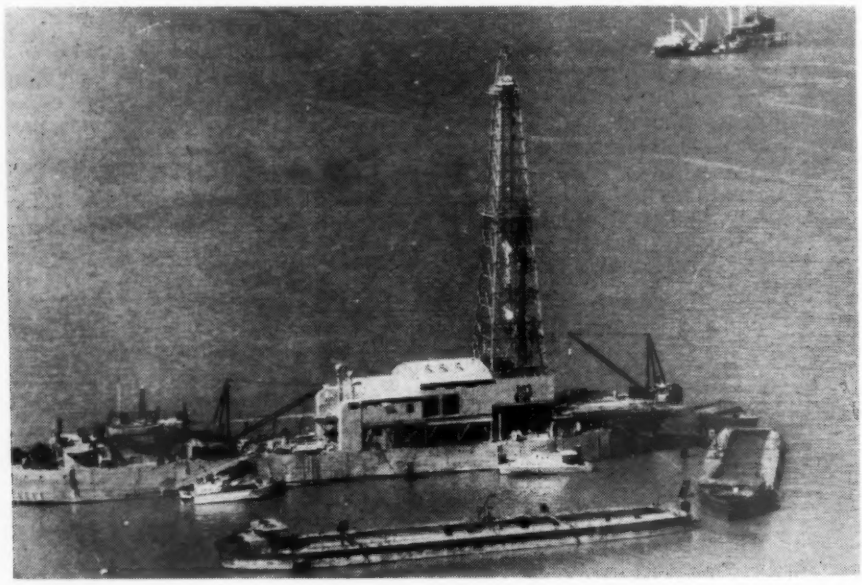
Not all of the drilling platforms installed in the Gulf of Mexico have been of the jacket type. Some have been built using conventional timber piles, caps, beams, decking, and bracing. Some others have consisted of large diameter steel piles with a system of cable braces. Huge submersible barges, or converted ships sunk on the Gulf floor have in a few instances been used in shallow water near the shoreline.[5] Submersible barges have been in use some twenty years for drilling in canals, lakes, and bays of the Gulf Coast region, and their use offshore was simply a widening of their scope. Drilling from a structure sitting on the bottom, however, is in general frowned upon because of the possibilities of uneven settlement due to poor soil, scour from currents, wave forces, and many other factors and conditions too numerous to discuss in detail. Several schemes have been advanced for offshore drilling by the use of barges submerged some distance below the water surface, but kept above the Gulf floor by buoyancy and the use of spud piles. Although some of these suggestions appear to be perfectly sound, none have been accepted by any of the oil companies nor have any been built. This is largely due to their tremendous first cost.

From the outset of the drilling program, there has been a sharp division between the operators concerning two kinds of drilling platform assemblages. One of these systems was that of a huge, self-contained, pile supported structure mounting all drilling rig equipment, mud storage, fuel and water, together with a separate platform, generally connected to the main structure by a steel foot bridge, for quarters for the personnel. In the other system, the pile supported structure was kept to a minimum size sufficient only for the drilling equipment and a drilling tender was anchored alongside.[6] This tender, usually a converted LST or YF Barge, provided for the balance of the drilling equipment, mud pumps and pits, pipe storage, dry mud and cement storage, fuel and water and quarters. In comparison, these two schemes both have advantages and disadvantages. It is now generally agreed



DRILLING is in progress. Vessel anchored alongside is a converted LST which provides quarters for men and storage for materials and equipment for which there is no room on platform. After completing a well deck, derrick, and equipment are skidded along four caps beams and another well started. This platform is for five wells.

A LST rigged up to serve as a drilling barge. Ship, as well as three small barges used as a breakwater are sunk on bottom. Upon completion of well LST is floated and pulled back. Slot in bow is provided for this purpose. This is a Shell well. A California Company jacket type structure with LST is shown in background drilling on same structure.



that for the drilling of wildcat wells the small platforms with tender is better, whereas the large, self-contained platform is preferable if the operator is assured that he will be able to drill and obtain production from a number of wells at one location. As a matter of fact, as many as 11 wells have been put down from one platform in the Gulf by means of directional drilling. By such means, it is possible to drill from a single platform a number of wells which will draw from the producing sand at regularly spaced intervals thus obtaining maximum recovery. These multi-wells platforms are arranged with skid beams so that the derrick and drilling unit can be slid a few feet for each well. By drilling the maximum number of wells possible from each single platform the cost per individual well is greatly reduced.

An idea concerning the tremendous size of some of these structures can be obtained from the following data. One of the largest self-contained structures had a main platform 172 ft long and 90 ft wide. Above the main platform were two upper decks covering more than 50 per cent of the lower platform area. The eight jackets and deck units required were entirely prefabricated onshore. Adjoining this main platform and connected to it by a foot bridge 80 ft in length was a quarter platform 106 ft long and 74 ft wide. Three steel buildings were situated on this platform, one for kitchen, dining hall, and food storage, one for sleeping quarters for 36 men and one for the office, radio room, recreation room, and quarters for the supervisors. These buildings were also entirely prefabricated and completely furnished before leaving land so that it was only necessary to pick them up and place them in their proper positions on the quarter platform to make living facilities immediately available. The main platform of this structure was supported by 123, sixteen-inch pipe piles driven through the columns of six jackets. Heaviest of these jackets, the one under the derrick and drilling rig, weighed 145 tons. Twenty-four piles, two deck sections, and two jackets were used in the quarters platform.

This structure was installed in 48 ft of water at a cost in excess of $750,000. Unfortunately, the three wells which were drilled from it failed to discover any oil, but they did encounter a large gas reserve. The wells are now shut in as the cost of a submarine pipe line is too great to justify the expenditure until further development of the field can be made.

The deepest water in which any platform has been erected is 62 ft. The single jacket used on this job was 78 ft high, 98 ft long, and 48 ft wide and weighed approximately 225 tons. Its size and weight were so great that it could not be handled by any derrick in the area and as a result, it was necessary to launch it from the end of a barge at the erection site.

Large and powerful floating equipment is needed for the erection of these structures. It is especially important that the barge on which the derricks are mounted be of unusual size as otherwise the prevailing swells, ranging from two to five feet in height will create so much sway at the boom tip that it becomes impossible to pick up and insert the piling in the jacket columns, spot the floating driver on these pilings, or pick up and place the prefabricated deck sections. None of the equipment originally available in the area proved entirely satisfactory for offshore construction. As a matter of fact, there are but few derrick barges in existence with capacity of one hundred tons or more which are mounted on barges of sufficient size to permit them to work in the open sea. Furthermore, most of the bigger derrick barges in use for river and harbor work do not have sufficient swing for this kind of service. Recognizing the inadequacy of the available equipment, J. Ray McDermott and Company, Inc. together with the Superior Oil Company, contracted for the construction of a derrick barge, which would be able to work without excessive sway in swells up to 8 ft. This unit completed in 1949, has a Wiley-Whirley derrick having a boom length of 190 ft with a rated capacity of 150 tons on an 80 ft swinging radius through the full 360 deg. The barge itself is 300 ft long, 90 ft wide, and 14 ft deep. Quarters for two complete crews were later added on the rear end of the barge. The customary practice on these jobs is to work around the clock seven days a week until the

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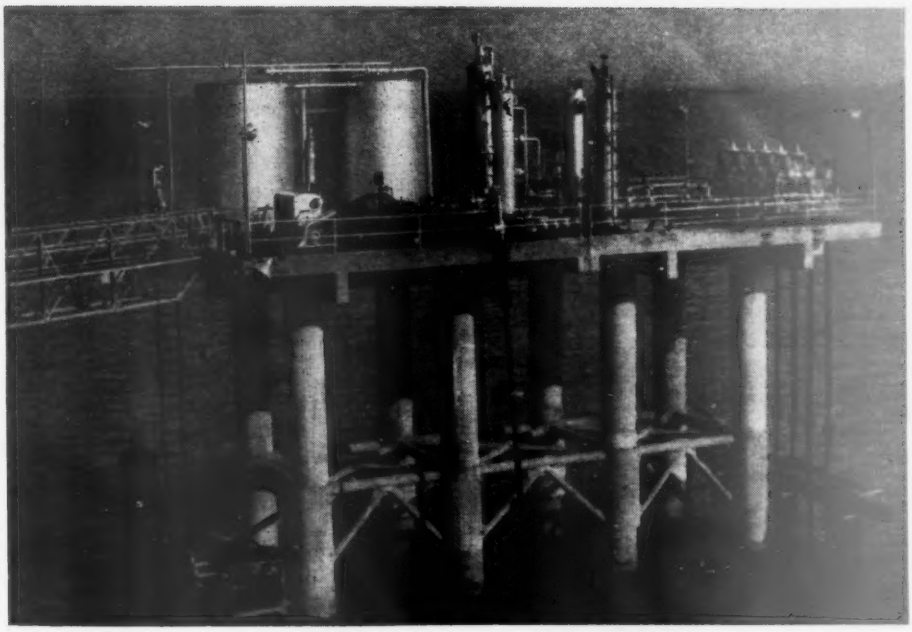
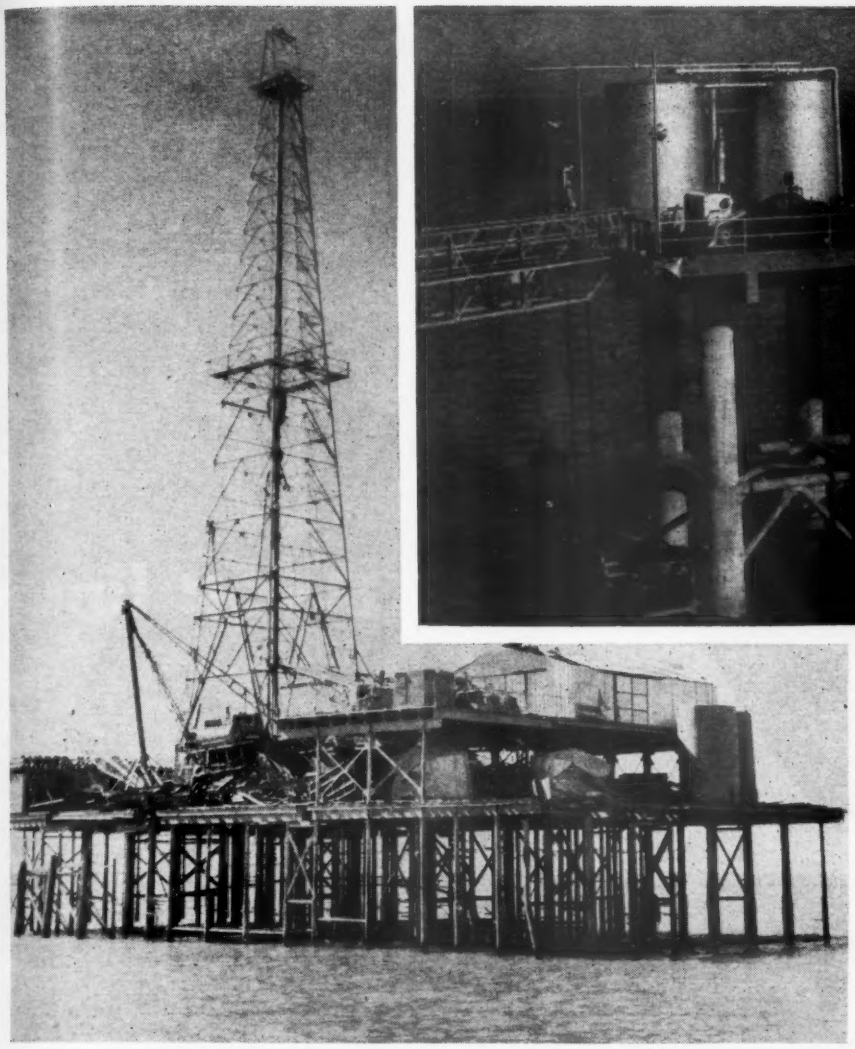


CLOSEUP of one of the 30 by 60 ft concrete production platforms on 36 in. OD prestressed concrete piles.



DRILLING structure as it appeared after being buffeted by hurricane.

work is finished, weather permitting.

After the structure is erected and the wells drilled, in fact from the instant construction is initiated, the sea commences another and more subtle form of attack. Various forms of marine life immediately commence their work of infesting and destroying any submerged timber incorporated in the structure. Steel above and below the water is subject to one or more of the various forms of corrosion such as electrolysis, electro-chemical action, sulphate reducing bacteria, and general atmospheric deterioration. Creosote treatment of timber will effectually prevent infestation by marine life until such time as creosote has bleached out. As very little wood is used in these structures, this is not an important problem. Corrosion, however, is of extreme importance and to date no effective methods of prevention has been developed except for the submerged portion of the structure to approximately one foot above normal low tide. Here corrosion can be successfully controlled by cathodic protection. The splash zone is subject to the most severe corrosion due to alternate wetting and drying and is most difficult to protect. Only at infrequent periods will the water be smooth enough to permit field application of protective coatings. Considerable success has been had by the installation of monel sheathing or steel sections in the jackets and bracing the insertion of monel and nickel clad throughout this zone. The installation of these special metals is undoubtedly well worth the large extra cost involved. The balance of the structure above the tidal and splash zone can be reached by paint at all times except during storms. Due to the salinity of the water the vapors are very destructive to ordinary paints which have but a limited service life. Experiments with metallizing and galvanizing throughout this area, indicate that this may be the best and cheapest protection for this zone.

The high cost of maintenance of steel structures has emphasized the need for either some far better methods of protecting them from corrosion or a complete change to a new material. Use of prestressed concrete has been given careful consideration and study for the past several years and designs are now complete. Beyond doubt many structures of this type will be fabricated and installed once the Gulf of Mexico again becomes an active drilling area. Actually, a number of concrete platforms have been constructed during the last two years, but these were built for use as producing facilities and not for drilling.[7] For drilling the structures will need to be much larger and stronger.

The concrete installations in use consist of prefabricated, but not prestressed concrete decks supported by hollow prestressed concrete piles 36 in. in diameter. The decks are made in sections 30 ft square and can be grouped together to give platforms 30 ft by 60 ft, 30 ft by 90 ft — 60 ft by 60 ft, etc. Each deck section is supported by four of the large concrete piles which are capable of supporting tremendous loads even in unconsolidated, cohesive soils of high water content. At one structure, recently completed, piles with approximately one hundred feet of penetration supported over one hundred and five tons. Analysis of cores taken at this location revealed that the soil was one of the weakest ever encountered, even in this area where soils of extremely low supporting capacity are the rule. Apparently these large piles, which displace over three cubic feet per foot of penetration, remould the soils through which they are driven and by this consolidation actually age and change them in a definitely beneficial manner.

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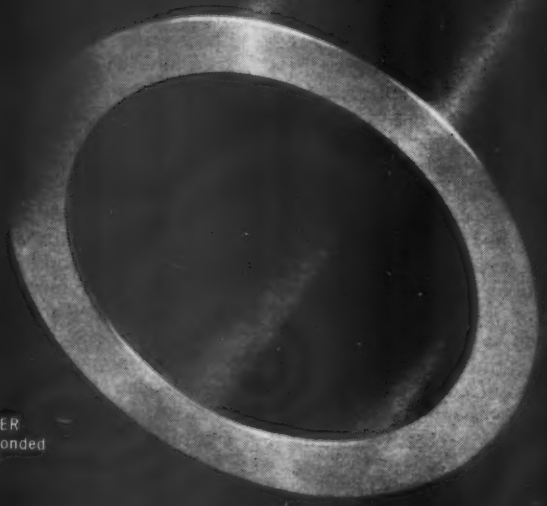

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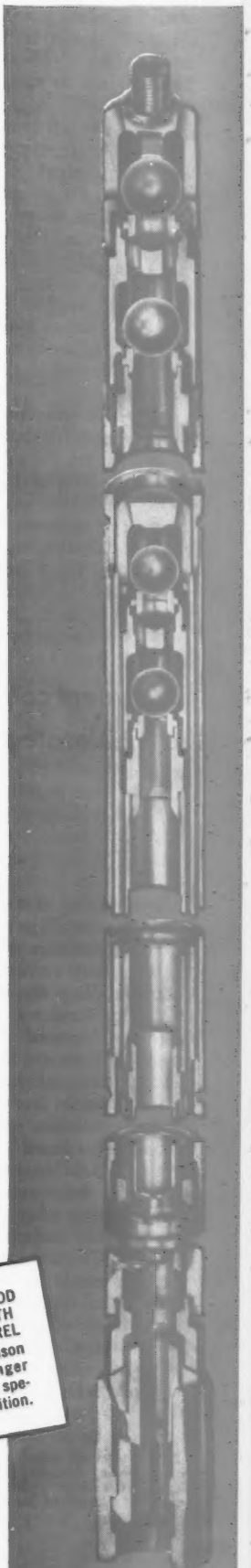

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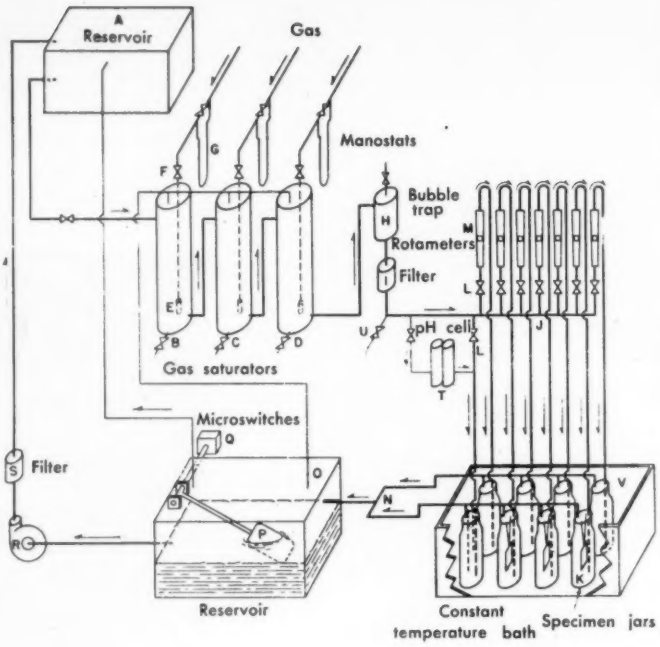

FIG. 1. CORROSION-TEST APPARATUS.

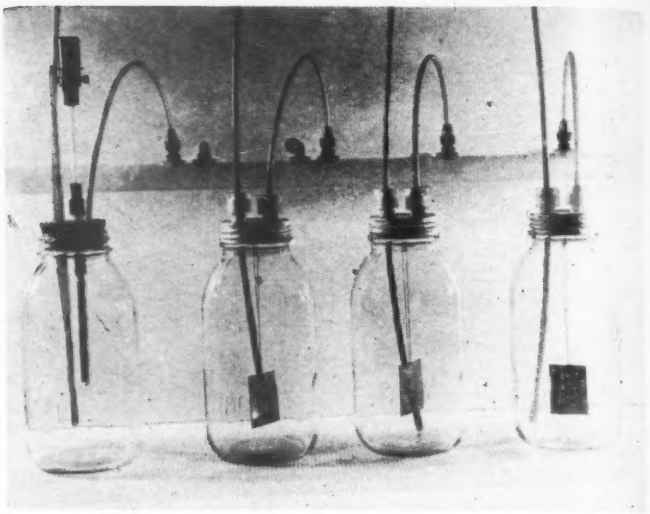

FIG. 2. CORROSION-TEST manifold, temperature-control, and corrosion-specimen jars.

Corrosive Action on Steel by Gases Dissolved in Water

Equipment corrosion in secondary recovery projects shown to be accelerated by action of gases dissolved in injected water

J. WADE WATKINS and JACK WRIGHT

Corrosion of metallic equipment is a serious economic problem in the production of petroleum and, particularly, in the secondary recovery of petroleum by water flooding. Despite the tremendous amount of fundamental and applied research performed on corrosion problems, few data are available concerning the corrosivity of dissolved oxygen, free carbon dioxide, and hydrogen sulfide in the concentrations and ratios and at the temperatures usually encountered under actual oil-field conditions. After a field study had been made of the corrosive and plugging characteristics of waters injected into subsurface formations, a series of 72-hour, dynamic laboratory tests was made to determine the corrosion caused to mild steel in water by the common dissolved gases, where all other controllable factors influencing corrosion were maintained constant. Data are presented concerning the corrosion to mild-steel test specimens caused by varying concentrations of oxygen, free carbon dioxide, and hydrogen sulfide.

*Presented at 123rd annual meeting, American Chemical Society, Los Angeles, California, March 16, 1953 under the title "Corrosive Action of Dissolved Gases on Steel in Water."

RESEARCH on the causes of and methods of minimizing corrosion has been conducted by many investigators over a period of more than 150 years abroad and more than 50 years in the United States. Speller[5] traces the history of corrosion studies through the inception of Calvert's acid theory, Friend's collodial theory, Bengough and Stuart's theory of direct oxidation, the biological theory, and the electrochemical theory. Most corrosion now is believed to be fundamentally electrochemical in nature. Many factors, however, influence the rate at which corrosion progresses and it often is difficult to evaluate the corrosive characteristics of a particular environment because of the variables involved.

Corrosion of metallic equipment in the production of petroleum has been a serious economic problem since the beginning of the industry. Some water is produced with crude petroleum, either in the free form or as emulsions, in nearly every oil-producing field. When large volumes of water or of acidic gases are produced with petroleum, corrosion is both extensive and severe. In secondary recovery, partly depleted petro-

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Jack Wright is a technologist for the Bureau of Mines in Bartlesville. He was employed with Dewey Portland Cement Company as a mix chemist and analyst from 1930 to 1941. From that year to 1944 he was with the War Department, U. S. Engineers.

leum reservoirs are repressured by injecting gas, air, or water into the producing formation through wells so located that the injected fluid forces the oil toward and into boreholes of oil-producing wells. Corrosion is a particularly serious economic problem in secondary-recovery projects because large volumes of gas and air or water, often having corrosive characteristics, must be handled in treating, distribution, and injection systems and because more wells (including injection wells) are utilized than in primary-production projects.

The cost of replacing corroded metallic equipment, the production time lost in effecting such repairs, and the shortage of steel pipe and other goods have caused petroleum producers in general and secondary-recovery operators in particular to place unusual emphasis during the past few years upon means of minimizing corrosion.

The widespread use of water flooding as a method of stimulating petroleum production in the eastern Kansas, northeastern Oklahoma, and north-central Texas regions of the Mid-Continent oil-producing area causes the corrosion problem to be particularly significant in that area. Water-flooding operators usually combat corrosion by the use of: (1) Corrosion inhibitors; (2) corrosion-resistant materials; (3) noncorrodible linings; (4) chemical treatment; and (5) cathodic protection. Although all corrosion-preventive measures have advantages, usually no one of these affords maximum protection; consequently, a combination of two or more frequently is used.

Chemists and engineers at the Bartlesville, Oklahoma, station of the Bureau of Mines made a comprehensive field study of water-flooding plants and systems in which water was conditioned and injected. Purpose of this study was to evaluate the comparative efficiencies of different methods used to condition and inject water, from the standpoint of minimizing corrosion and preventing the plugging of the producing formation at water-input wells, and to investigate possibility of improving existing methods or of devising new ones. Methods employed in making field corrosion tests and chemical analyses were described in a journal article,[7] and details of the field study were given in a recent Bureau of Mines publication.[8]

As a result of information obtained during the field study, the following observations were made: (1) Some waters are more corrosive after conditioning, at the point of injection, than are the same waters at their source; (2) most of the corrosion in water systems is caused by dissolved gases; (3) considerable diversity of opinion exists among water-flooding operators concerning the magnitude of corrosion caused by the different dissolved gases; and (4) evaluation of dissolved-gas corrosion under field conditions where other variables cannot be controlled is impracticable.

Despite the tremendous amount of work done on the basic causes for and methods of controlling corrosion, information concerning the comparative corrosivity of dissolved oxygen, free carbon dioxide, and hydrogen sulfide in the concentrations and at the temperatures usually encountered in field operations could not be found in the literature on the subject. Consequently, laboratory apparatus was assembled for evaluating the corrosion of steel in water caused by different concentrations of those gases with other controllable factors influencing corrosion maintained constant. Three complete series of tests have been conducted, using as corroding mediums dissolved oxygen in the concentrations up to the maximum soluble from air at normal atmospheric temperatures (2 to 8 ppm), dissolved free carbon dioxide at concentrations ranging from 20 to 750 ppm, and dissolved hydrogen sulfide at concentrations ranging from 5 to 2640 ppm. Data obtained from these tests are given in this paper. A comparative graphical representation also is given of the corrosion caused by the three gases at the cited concentrations, which are those frequently found in waters available for subsurface injection.

Apparatus

Fig. 1 is a flow diagram of the laboratory dissolved-gas corrosion apparatus. This equipment was constructed entirely of plastic, hard rubber, and glass to prevent intensifying of corrosion through galvanic action, to insure a more constant temperature by providing better insulation, and to permit observation of physical effects within the system.

Water from the upper reservoir (A) gravitates through cylindrical saturators (B, C, and D), where gas is dispersed into the water through diffusion disks (E). Gas is supplied from pressure cylinders, and the amount entering each saturator is controlled by pressure-regulator valves (F) and measured by manometers (G). The gas-saturated water gravitates from the saturators through a bubble trap (H), where any excess gas is released, through a filter (I) containing glass wool and sponge plastic to remove corrosion products from the water stream, and into a water-distribution manifold (J). Water flowing from the manifold is admitted to corrosion-specimen jars (K) through plastic-seated needle valves (L) at controlled rates measured by rotameters (M). The effluent from the specimen jars flows through a manifold (N) into the lower reservoir (O). The water level in this reservoir is regulated by a plastic float (P) that operates micro switches (Q) that start and stop the motor on a hard-rubber gear pump (R). The pump forces the water through a second filter (S) into the upper reservoir, from where the water is recycled. The pH value of the water is recorded by a meter having an electrode (T) inserted into the system, and samples of the water for analysis are obtained at intervals through a sampling tap (U). Temperature of the water in the water bath (V) is maintained constant by a heating element and cooling coils, controlled by a thermoregulator.

Water bath accommodates seven corrosion specimen jars and an eighth jar that contains the thermoregulator and an indicating thermometer. Fig. 2 shows the water-distribution manifold, three of the corrosion-specimen jars, and the temperature-control jar. One-half-gallon glass jars are used as specimen containers. Plastic caps are held in place on the jars by brass jar rings. The plastic influent line extends to within one-half inch of the bottom of the jar, and the bottom of the plastic effluent line is flush with the bottom of the cap, making it possible to maintain the jar completely full of water during the tests. The corrosion specimens are suspended in the jars by nylon cord as shown.

Corrosion specimens 35 mm wide and 50 mm long are cut from mild steel shim stock 1 mm thick. Results obtained in making field corrosion tests indicated that more reproducible results were obtained by using shim stock than by using sheet steel, which is less uniform in composition.

The corrosion specimens are precorroded in a 2 per cent solution of propionic acid at 45 C for 1 hour to prevent erroneous initial weight losses caused by irregularities in the surface finish of the steel. After precorrosion the specimens are scrubbed with water and scouring powder by using a stiff brush for aproximately 1½ minutes, rinsed first in distilled water and then in acetone, air dried, weighed, and stored in a desiccator over a drying agent until they are used.

Test Method

Before a corrosion test is made, water is cycled in the apparatus until the operating temperature of 80 F is reached and maintained. This temperature was selected as being as near an average of field water temperatures as possible, considering that, even in cold weather, waters produced from deep formations remain fairly warm throughout the water distribution and injection system. After the temperature is stabilized, gas is dispersed into the water, and cycling is continued until the desired gas concentration remains constant. When one gas only is used, that gas is introduced into the first or second saturator at a selected rate and its concentration in solution is controlled by the dispersion of nitrogen into the third saturator. When a ratio of two gases is being used, one gas (for example, oxygen) is dispersed in the first saturator, the second gas (for example, carbon dioxide) is dispersed in the second saturator, and the ratio of concentration of the gases is controlled by the dispersion of nitrogen in the third saturator.

When stability of the gas concentration is obtained, the corrosion specimens are placed in the specimen jars, and the test is conducted for a period of 72 hours. During this time, the temperature of the corrodent is maintained with an average deviation of 0.2 deg and a maximum deviation of 0.5 F. The pH of

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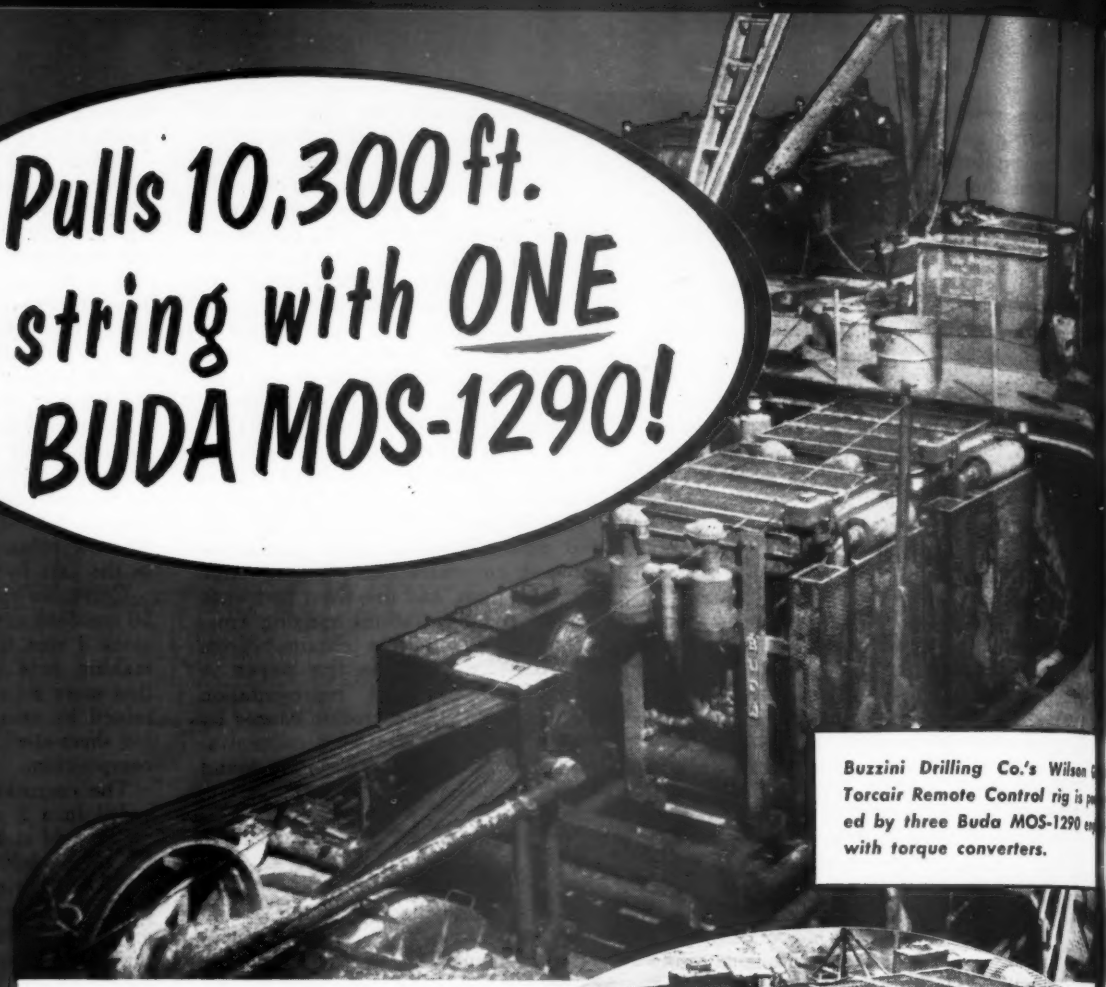

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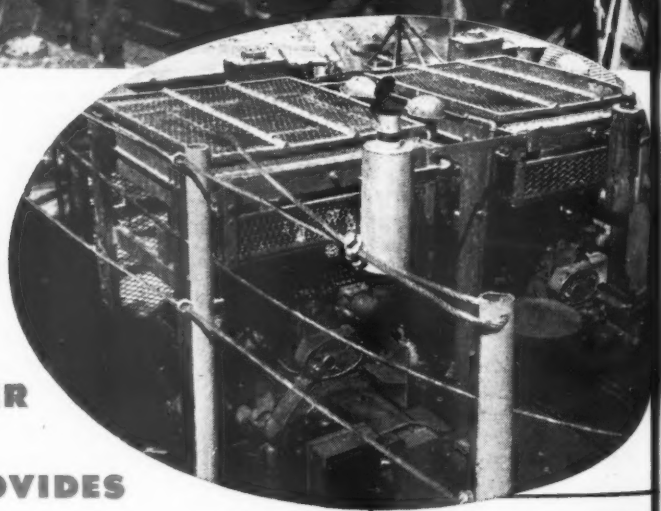

Close-up of the [illegible] rig's two compounded Buda [illegible] 1290 pump and drawworks [illegible] Note top mounted radiators.

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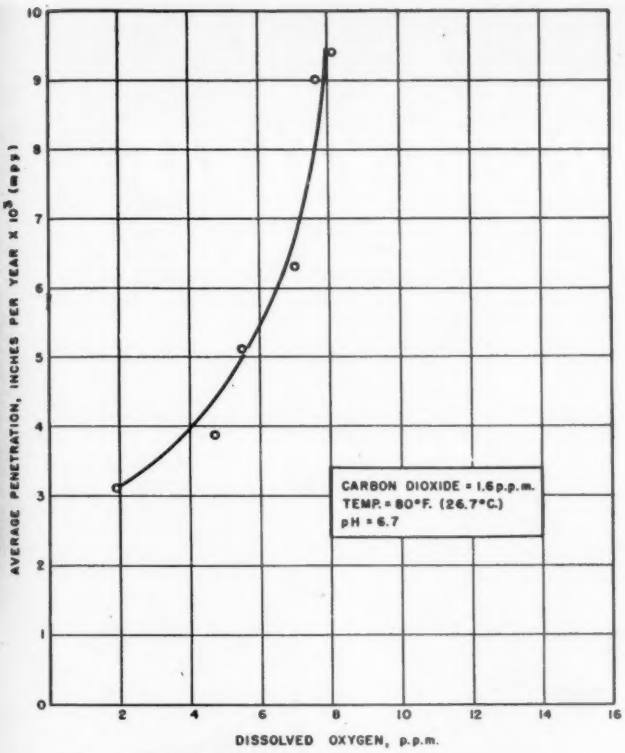

FIG. 3. CORROSIVE action of oxygen on steel in distilled water.

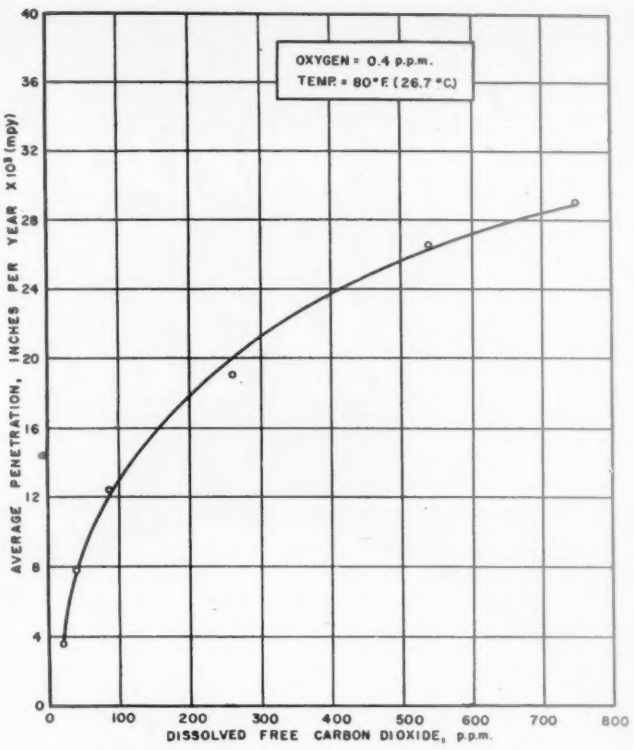

FIG. 4. CORROSIVE action of free carbon dioxide on steel in distilled water.

the solution is continuously recorded, and samples of the water taken at intervals are analyzed to determine quantitatively the concentration of dissolved gases. Adjustments of the pressure-regulator valves are made as necessary to maintain the desired gas concentrations. The velocity of the fluid past the test specimen is maintained quite closely at 0.05 centimeter per second. This velocity was selected as great enough to change the water in contact with the corrosion specimen constantly without turbulence that might wash corrosion products from the surface of the specimen.

At the conclusion of the test, the specimens are removed from the water-filled jars and inspected, and the nature and quantity of corrosion products are recorded. The specimens are wiped to remove loose corrosion products from the surface, and they are scrubbed again as previously described. The specimens then are placed in a solution of 10 per cent ammonium citrate and 10 per cent ammonium hydroxide at 55 C for 1 hour. At the end of this interval, the specimens again are scrubbed, rinsed in distilled water and acetone, air dried, and weighed to determine the loss in weight. One noncorroded specimen is cleaned in the same manner and for the same length of time as the corroded specimens to determine the loss in weight caused by cleaning alone. This loss is deducted from the total weight loss of each specimen, and the difference in weight loss is considered to be caused by corrosion. Three to seven specimens are used in each corrosion test, and an average of the weight losses is used as the value for corrosion loss at that particular gas concentration. These values are converted from milligrams per specimen to average penetration per year in thousandths of an inch (mpy).

Oxygen Corrosion Tests

Results of several tests conducted to determine the corrosivity of dissolved oxygen in different concentrations are graphically shown in Fig. 3. Concentrations of dissolved oxygen used ranged from 1.9 to 8.2 ppm, the maximum saturation from air at the prevailing temperature and atmospheric pressure. Free carbon dioxide was present at an average concentration of 1.6 ppm, and the pH value averaged 6.7. The shape of the oxygen curve is typical of those reported by other investigators[6] when the tests were made in the presence of negligible quantities of dissolved free carbon dioxide and at moderate but higher temperatures. At the conclusion of each test, specimens were covered with a loose, red, porous coating of ferric hydroxide, under which—next to the surface of the specimen—was a thin, tenacious black coating of an intermediate iron oxide. After cleaning, pits and blisters typical of oxygen corrosion were observed on the surface of the specimens. The amount of the iron oxides present and the extent and depth of pits were roughly proportional to the concentration of dissolved oxygen used in each test.

Carbon Dioxide Corrosion Tests

Fig. 4 illustrates graphically the corrosion caused by concentrations of dissolved carbon dioxide ranging from 20 to 750 ppm. Dissolved oxygen was present at an average concentration of 0.4 ppm. The pH value ranged from 5.4 to 4.0. The shape of the curve resembles curves made from data obtained using lower concentrations of carbon dioxide and higher operating temperatures.[6] The principal corrosion product present on the surface of the exposed specimens was a hard, black scale, which probably was magnetic iron oxide. Pits were sharper and deeper than in the oxygen-corrosion tests but were less numerous. These conditions are typical of carbon dioxide corrosion, as pointed out by Prange.[3]

Hydrogen Sulfide Corrosion

Corrosion losses caused by concentrations of dissolved hydrogen sulfide ranging from 2 to 2640 ppm are graphically presented in Fig. 5. The pH value of the water ranged from 4.8 to 3.2 in the various tests. As shown by the curve, hydrogen sulfide corrosion increased rather sharply from low concentrations up to a concentration of approximately 150 ppm. From 150 to about 400 ppm corrosion remained essentially constant, and between 400 and 1600 ppm, corrosion rapidly diminished. Above 1600 ppm, up to 2640 ppm, the corrosion rate again became nearly constant with the result that little more corrosion occurred in this concentration range than at 5 ppm. Repetitive tests were made at some of the higher concentrations to confirm the results of the previous tests, and a reasonable check was obtained. Iron sulfide was formed in all of the hydrogen sulfide corrosion tests, in greater quantities at high concentrations of the gas, and in maximum quantities at the concentrations causing maximum corrosion (150 to 400 ppm). Quantity of iron sulfide formed in the tests where maximum corrosion was ob-

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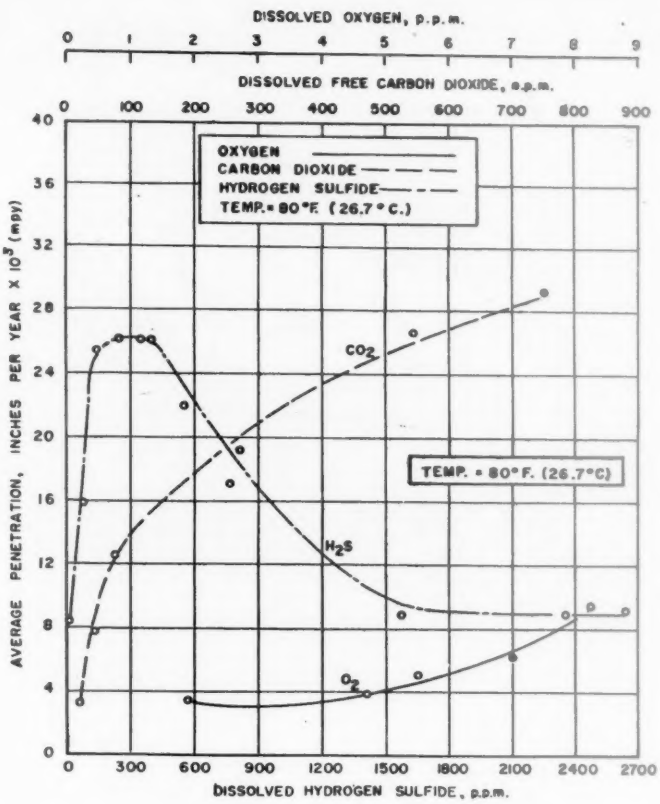
FIG. 6. RIGHT — COMPARATIVE corrosive action of oxygen, free carbon dioxide and hydrogen sulfide on steel in distilled water.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DISSOLVED FREE CARBON DIOXIDE, p.p.m.
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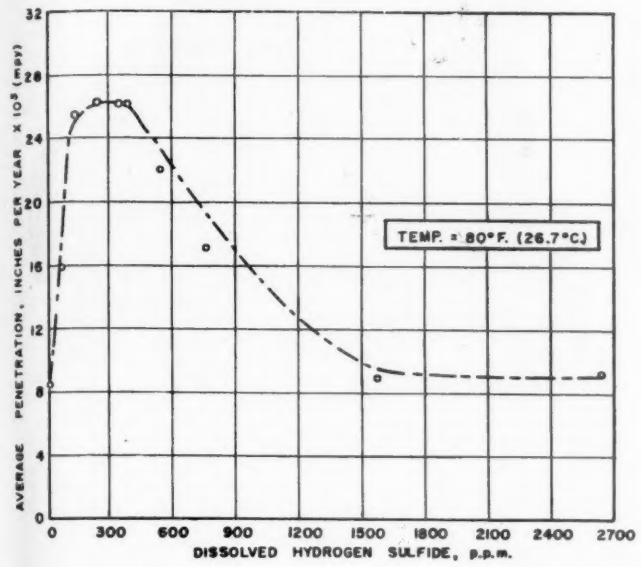
OXYGEN
CARBON DIOXIDE
HYDROGEN SULFIDE
TEMP. = 80°F. (26.7°C.)
AVERAGE PENETRATION, INCHES PER YEAR X 10³ (mpy)
0 4 8 12 16 20 24 28 32 36 40
CO_2
H_2S
O_2
TEMP. = 80°F. (26.7°C)
0 300 600 900 1200 1500 1800 2100 2400 2700
DISSOLVED HYDROGEN SULFIDE, p.p.m.

FIG. 5. BELOW — CORROSIVE action of hydrogen sulfide on steel in distilled water.


AVERAGE PENETRATION, INCHES PER YEAR X 10³ (mpy)
0 4 8 12 16 20 24 28 32
TEMP. = 80°F. (26.7°C)
0 300 600 900 1200 1500 1800 2100 2400 2700
DISSOLVED HYDROGEN SULFIDE, p.p.m.

tained was so great that the sulfide settled to the bottom of the corrosion-specimen jars in large quantities and was filtered out of the flow stream by the two filters in the system. Examination of the corroded specimens after cleaning revealed numerous blisters but very few pits on the surface of the specimens. The surface of the specimens exposed to maximum concentrations of hydrogen sulfide had a tenacious, dark coating that normal cleaning procedures would not remove. Under the blisters the metal was quite bright. When the blisters were scraped from the specimens, however, any pits present were so shallow as to be imperceptible.

It is recognized that much remains to be learned concerning the reactions involved in hydrogen sulfide corrosion. In many instances field corrosion tests made with waters containing dissolved hydrogen sulfide did not reveal as much corrosion as was expected. It was known that metallic equipment in contact with the same waters was being severely corroded. This phenomenon led to the supposition that the iron sulfide coating had an inhibiting effect in the early stages of corrosion and later, through some chemical change in environment, caused the acceleration of corrosion. One consideration was that elemental sulfur, when present in sufficient quantities, acted as a catalyst, which accelerated the sulfide-corrosion mechanism.

Several authorities[1,2,5] have suggested that the presence of oxygen in minute quantities causes an increase in sulfide corrosion by the formation of sulfuric acid. Neither, however, in the corrosion tests made and conditions observed in the field nor in the laboratory corrosion tests was there any likelihood of more oxygen being present at one time than at another. Neither does the theory of a sulfur catalyst explain the decelerated corrosion at the higher concentrations in the laboratory tests.

The apparent passivity of specimens exposed to maximum concentrations of dissolved hydrogen sulfide and the tenacity of the sulfide coating on those specimens led to the conjecture that the coatings deposited on the specimens in the different sulfide-concentration ranges differed chemically, possibly because of the formation of polysulfides when greater quantities of dissolved hydrogen sulfide were present. To determine whether corrosion was inhibited by the coating, two specimens were exposed to saturated hydrogen-sulfide water for 72 hours, cleaned, and reweighed. Two other specimens were exposed to a concentrated solution of ammonium polysulfide, cleaned and reweighed. Those four specimens, together with two not previously corroded were exposed to water containing an average of 230 ppm of dissolved hydrogen sulfide for the usual 72 hours. Results of the tests showed that the specimens previously exposed to the saturated hydrogen-sulfide water had the lowest corrosion-weight losses, those exposed to ammonium polysulfide had intermediate corrosion weight losses, 30.7 per cent greater than the lower two, and the untreated specimens had the greatest corrosion-weight losses, 5.3 per cent greater than the intermediate two and 37.4 per cent greater than the lowest two specimens. This evidence appeared to corroborate the assumption that corrosion inhibition was afforded by the coating deposited on the specimens at high concentrations of hydrogen sulfide. The exact nature of the coatings formed and the chemical difference, if any, have not been determined. Further work on the mechanism of corrosion at high concentrations of hydrogen sulfide may lead to explanation of this phenomenon.

Comparative Corrosivity of Dissolved Gases

Fig. 6 gives a graphical comparison of the corrosion caused by comparable quantities of the three dissolved gases. The oxygen and carbon dioxide corrosion curves are exaggerated horizontally in this figure to permit easier reading of the respective gas concentrations. It is shown that oxygen in small concentrations is much more corrosive than the other two gases. Oxygen often is considered to be the chief cause of steel corrosion; however, from a practical standpoint, oxygen will be present in waters only to the extent of its solubility from air, or less than 9 ppm. Also, Speller[5] points out that the rate of corrosion of iron in water saturated with hydrogen sulfide (free from oxygen) is greater than in the same water saturated with air but free from hydrogen sulfide. This is illustrated in the graph.

These curves illustrate the practicality of the general practice of water-flooding operators in aerating waters containing dissolved acidic gases before treating and injecting the waters, even though oxygen is dissolved in the water during aeration.

Oxygen-Carbon Dioxide and Carbon Dioxide-Hydrogen Sulfide Corrosion Tests

Numerous laboratory corrosion tests also have been made with varying ratios of oxygen to free carbon dioxide as the corroding mediums where first oxygen is

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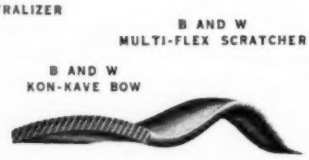

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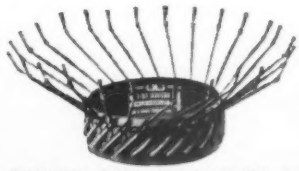

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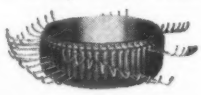

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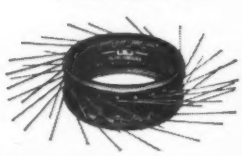

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maintained constant, with the carbon dioxide concentration varied, and in other tests where carbon dioxide is maintained constant, with the oxygen concentration varied. Data obtained from these tests, however, are not complete enough for release at present and will be reported at a later date.

Corrosion tests also will be made with varying ratios of dissolved free carbon dioxide to hydrogen sulfide with first the concentration of one gas, and in other tests, the concentration of the other varied.

Summary

Much work remains to be done on the corrosion of steel by high concentrations of carbon dioxide and hydrogen sulfide in oil-production and water-injection systems. Shock and Sudbury[4] have reported the results of extensive field observations and laboratory tests to determine the corrosivity of carbonic acid and acetic acid in gas-condensate and oil-producing wells. Hydrogen sulfide corrosion, however, has not been thoroughly investigated, and many data may yet be obtained concerning it.

It should be stressed here that the corrosion data as presented were obtained with the variables of temperature and velocity maintained constant and with other factors influencing the rate of corrosion, such as galvanic action, eliminated insofar as possible. Consequently, use of these data in predicting corrosion will be strictly applicable only under similar conditions. It is believed, however, that they may be used as criteria with reasonable accuracy if it is recognized that much corrosion may be caused primarily by other factors.

Acknowledgements

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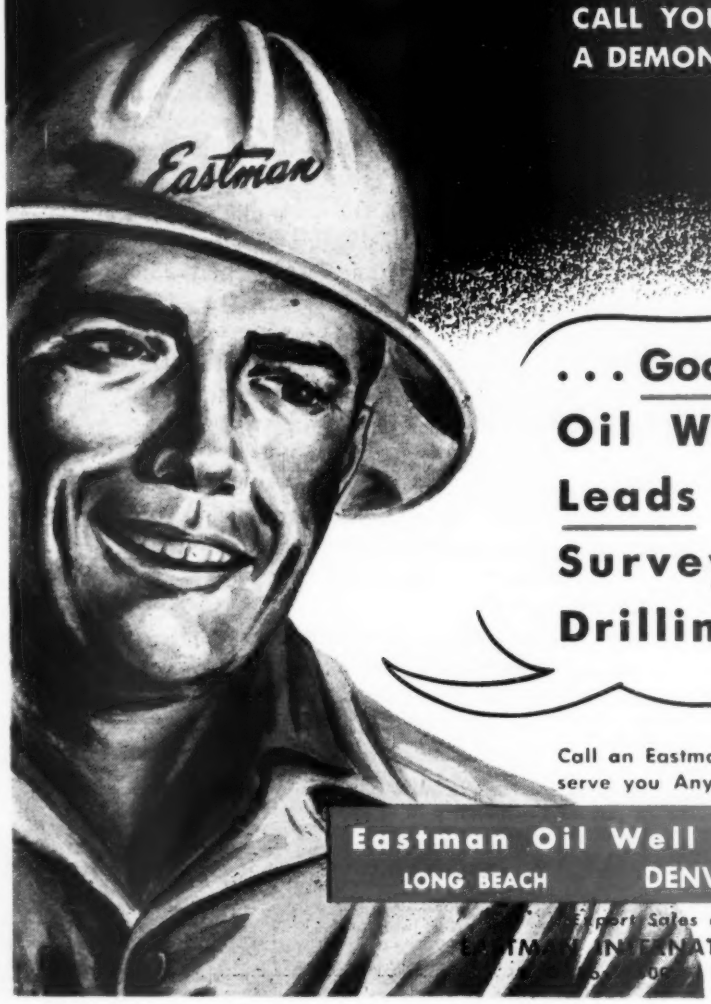

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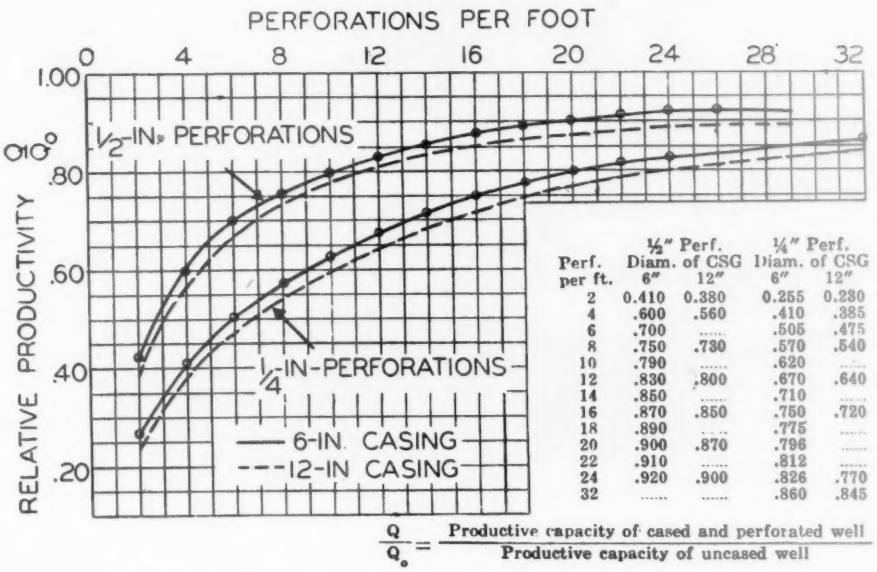
Factors Affecting Perforated Completions

Investigation of patterns, penetrations, and formation effect vital in proper gun selection

ROBERT E. BUSH*

IN the early days, the gun perforator was primarily a means of recovering oil that had been cased off and could not be reached through the well bore without resorting to some such procedure. But with maturity, the use of perforated completions is the rule rather than the exception in most areas, and with this acceptance has come a variety of problems. Deeper drilling, higher temperatures, better cement jobs, casing scratchers, centralizers, higher tensile strength cement and a myriad of other problems have been introduced, making it more difficult to reach the all important pay. With these obstacles, additional developments were necessary. As early as 1939 a gun was designed capable of penetrating more steel, more cement, and further into the formation. Unfortunately, the war stopped the development of new guns, and it was not until 1946 that more powerful guns were available for use in the oil fields. About this same time, the Monroe principle was put to use in the form of shaped charge perforating which gave even greater penetration. Developments are now underway for guns of both types to provide deeper penetration, better hole characteristics, less burr, etc. Although elaborate, modern, new laboratory apparatus was used in the development of these new guns, essentially the same old cut and try process remained the criterion for choosing the gun to be used in a well. The size of the gun, the size of the bullet, and the size of the hole made in the pipe are not always seriously evaluated.

An examination of the major factors affecting perforated completions might perhaps develop a greater understanding of the requirements of a perforated completion. It will be the objective of this discussion to attempt to review some of the requirements of perforated completion and the factors that contribute to their effectiveness. To assist in this analysis, we should take advantage of the theoretical work that has been done, as well as the practical or performance evaluation work that has been done.



Perf. per ft.	½" Perf. Diam. of CSG 6"	½" Perf. Diam. of CSG 12"	¼" Perf. Diam. of CSG 6"	¼" Perf. Diam. of CSG 12"
2	0.410	0.380	0.255	0.230
4	.600	.560	.410	.385
6	.700	.....	.505	.475
8	.750	.730	.570	.540
10	.790	.....	.620	.....
12	.830	.800	.670	.640
14	.850	.....	.710	.....
16	.870	.850	.750	.720
18	.890	.....	.775	.....
20	.900	.870	.796	.....
22	.910	.....	.812	.....
24	.920	.900	.826	.770
32	.....	.....	.860	.845

$$\frac{Q}{Q_o} = \frac{\text{Productive capacity of cased and perforated well}}{\text{Productive capacity of uncased well}}$$

FIG. 1. EFFECT of number of perforations on well productivity.

Factors Affecting Perforating

In a discussion as brief as this one, it would be impossible to cover all factors affecting perforated completions. Such factors as assurance of accurate placement of perforations, perforating gun performance, correlation of measurements with well logs, and the problems involved in wire line operations, are all certainly important factors in obtaining the desired results. These factors have been discussed at length by others and will not be referred to in this discussion; rather, the factors that are most pertinent to the characteristic of the type of perforation, its depth of penetration, and the effect of the perforation on the formation will be considered.

Size of Perforating Gun. As a perforating gun must necessarily be run in the size casing that has been set, the first consideration is to be able to run the gun in and out of the casing to be perforated. The easiest way to assure proper clearance would be, of course, to use a gun much smaller in diameter than the inside diameter of the casing. This solution, however, is not satisfactory because a considerable amount of energy must be expended within the inside of the casing, in the drilling fluid. In the case of bullet perforators, the energy expended in penetrating the well fluid is relatively smaller than the energy expended in the case of a shaped charge perforator; but with either type of perforator, conservation of energy for actual formation penetration should always be a guiding factor. For this reason, it is important to select the largest size perforator that will safely run in the casing that has been set. It is felt that the radial clearance between the perforator and the casing should not exceed .6 of an inch under ideal conditions. Where heavy muds are encountered these specifications may be difficult to meet due to the length of time required to run a gun of small clearance into a well that contains heavy mud with any reasonable speed. For this reason it is important to select the gun that will give the minimum clearance commensurate with the mud conditions.

Number of Perforations Per Foot. Many conflicting opinions have been offered regarding the number of perforations per foot that are necessary to obtain desired results. The argument is still not settled; however, by examination of the available information, a better understanding of the effect of the number of perforations may be had. In the 1930's, results obtained were the criteria for determining the

*Lane-Wells Company.

EXCLUSIVE

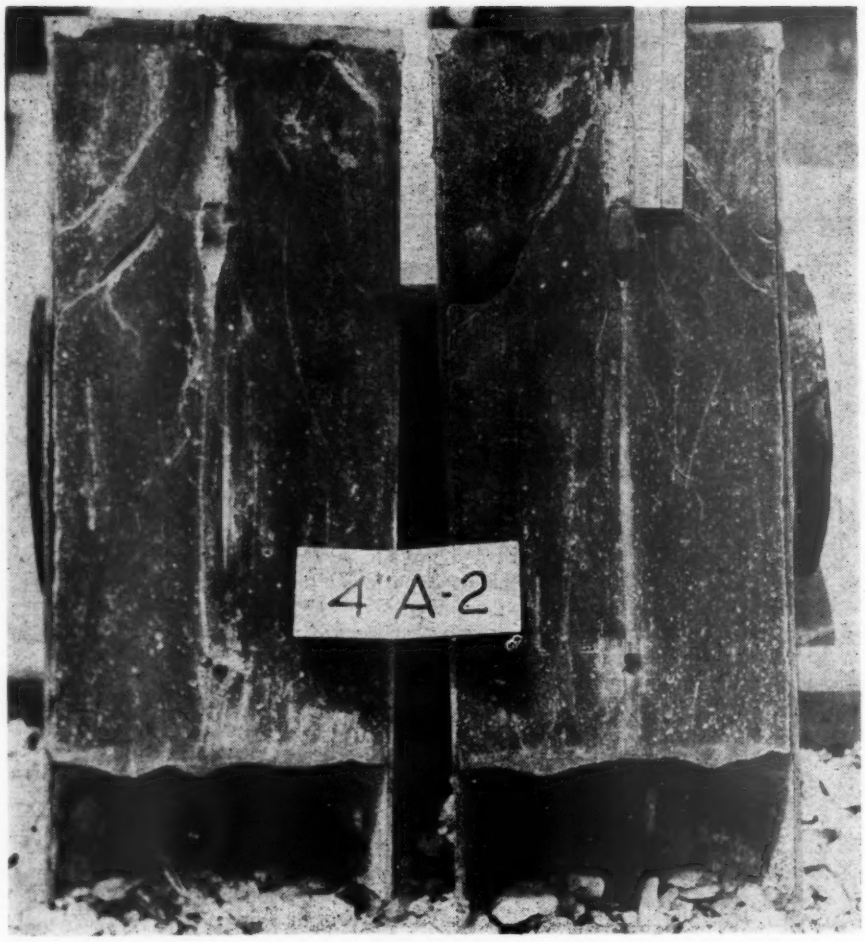


FIG. 2. STANDARD target is composed of .350 in. of steel, J55 or equivalent, backed up by 15 in. of 450-550 psi tensile strength neat cement as homogeneous and free of air as possible and cured for 14 days at 70 F. The target material should be confined.

perforation density. Early in 1942, a significant contribution was made by Morris Muskat[1] in the form of a paper, which appeared in the A.I.M.E., discussing the effect of increasing shot density as high as 32 shots per foot. The data presented is shown in Fig. 1. It was assumed that the ultimate objective of any perforated completion is to equal the production that would have been obtained from this well bore uncased. By comparing the ratio of productivity in open hole to that in cased hole, the effect of increased shot density was determined mathematically, assuming penetration through the pipe and cement sheath only. These data would indicate that a shot density of thirty-two shots per foot with this limit of penetration would not achieve the results of open-hole production. For this reason, more emphasis was given to increasing the shot density per foot. It was observed, however, that while shot density was increased, production apparently did not increase accordingly in many cases. It should be noted that the data shown in Figure No. 1 assumes no penetration into the formation, which is a most important factor.

Depth of Penetration. Penetration through the casing, the cement, and into the formation in the early days of perforating assumed the greatest importance when the perforating device was not capable of obtaining contact with the formation. Primarily, in an effort to assure adequate contact with the formation, more powerful perforators, capable of deeper penetration, were designed as has been previously mentioned.

To measure the degree of improvement, it was necessary to establish some standard for measuring the changes in the penetration ability of the perforating device. It was found that the target giving the most consistent results consisted of a stack of mild steel bars one inch thick, making it possible to detect even slight improvements in penetration ability.

Although the steer bar target offers an excellent callibration tool, it is not closely related to the resistance to penetration offered by the cement sheath and by the formation itself. A target more representative of the actual well conditions is a cement target which will be referred to in this discussion as a standard target. This target is composed of cement poured into a steel receptacle and allowed to harden to a tensile strength of 450 to 550 psi. The casing is represented by a plate of steel welded on the face of the target. The steel plate used in the standard target is .350-in. in thickness and is equivalent to J-55 or better. The prepared standard target is cured under water for fourteen days at 70 F. By firing the gun perforator into the standard target a better approximation may be made of its actual performance in the formation. Fig. 2 shows a picture of a typical standard target. Fig. 3 is a graph showing the performance of various types of gun perforators in the standard target.

The average specific gravity of the cement of a standard target has been measured as 1.59 gms, per cc. The density of loosely consolidated Miocene sands will range from 1.90 to 2.05. While there is no direct correlation between density and resistance to penetration, it is known that the higher the density, the greater the resistance to penetration. This would indicate that the standard target then is representative of a formation which offered less resistance to penetration than a loosely consolidated Miocene sandstone. Performance tests of this type have made it possible to more intelligently estimate penetration obtained in various types of formation.

While depth of penetration has been recognized as an important factor, its real importance was more clearly emphasized by a later work of Morris Muskat[2] and James L. McDowell, in which they reported the results obtained by using an electrolytic model to compare fluid flow in an open hole completion to the fluid flow in cased hole completion. This work was reported in the *Journal of Petroleum Technology*, Volume 189, 1950. In this same publication, a paper by R. A. Howard and M. S. Watson, Jr.[3] reported similar results obtained with an electrolytic model. These studies utilized scale models in which well bore diameters, and the diameter of perforations, could be represented by copper wires and copper tubing, making it possible to evaluate the ratio of productivity in a simulated open hole completion to the productivity in a simulated cased hole completion at various depths of penetration and numbers of perforations per foot.

Fig. 4 is a graph which demonstrates the effect of depth of penetration, number of perforations per foot, and the size of the perforation on the well productivity as compared to the productivity in open hole. The results of these studies indicate the following:

1. Earlier studies in regard to number of perforations, when penetration does not extend beyond the casing and cement sheath, were re-confirmed.

2. These studies suggest that the depth of penetration is extremely important to the productivity of a well.

3. They suggest that if we can assume there is no formation damage during the drilling of a well, no damage caused by the cementing process, and no damage during the perforating process, it would be possible for a perforated completion to equal and

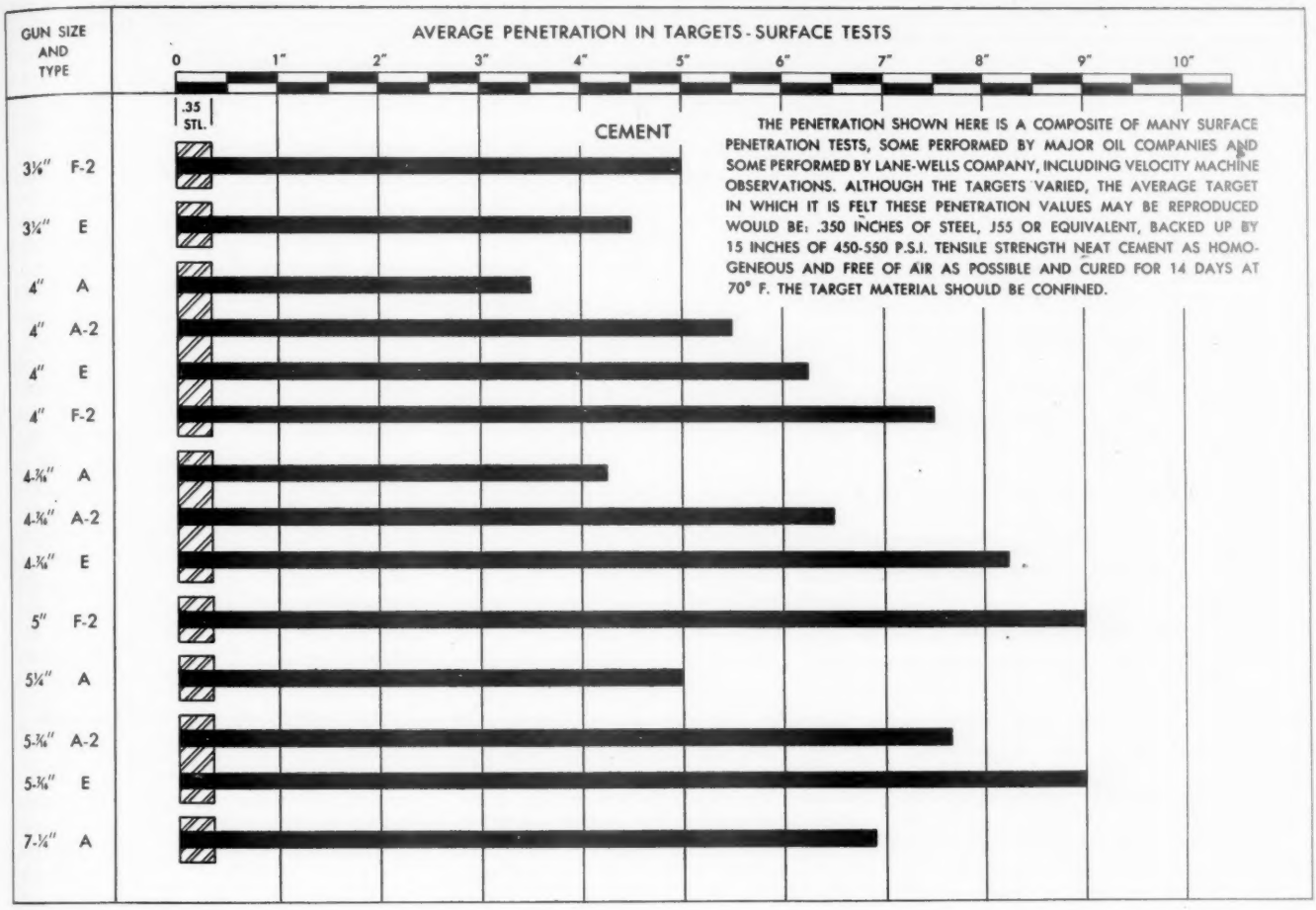

GUN SIZE AND TYPE
AVERAGE PENETRATION IN TARGETS - SURFACE TESTS
0
1"
2"
3"
4"
5"
6"
7"
8"
9"
10"
.35 STL.
CEMENT
3⅛" F-2
3¼" E
4" A
4" A-2
4" E
4" F-2
4-¾" A
4-¾" A-2
4-¾" E
5" F-2
5¼" A
5-¾" A-2
5-¾" E
7-¼" A
THE PENETRATION SHOWN HERE IS A COMPOSITE OF MANY SURFACE PENETRATION TESTS, SOME PERFORMED BY MAJOR OIL COMPANIES AND SOME PERFORMED BY LANE-WELLS COMPANY, INCLUDING VELOCITY MACHINE OBSERVATIONS. ALTHOUGH THE TARGETS VARIED, THE AVERAGE TARGET IN WHICH IT IS FELT THESE PENETRATION VALUES MAY BE REPRODUCED WOULD BE: .350 INCHES OF STEEL, J55 OR EQUIVALENT, BACKED UP BY 15 INCHES OF 450-550 P.S.I. TENSILE STRENGTH NEAT CEMENT AS HOMOGENEOUS AND FREE OF AIR AS POSSIBLE AND CURED FOR 14 DAYS AT 70° F. THE TARGET MATERIAL SHOULD BE CONFINED.

FIG. 3. PERFORMANCE of various guns in standard targets.

perhaps even exceed the productivity of an open hole completion.

In Fig. 4 it will be noted that with eight perforations per foot, one-half inch in diameter and of a depth equal to the diameter of the well bore, the productivity of open hole would be exceeded by a cased and perforated completion. As it is always the objective of any completion to make available the greatest productivity of which the formation is capable, it should therefore, be important to seek to obtain the greatest depth of penetration.

It should be recalled that the basic assumption is made in the electrolytic model studies that there is no change in the formation when the well bore is cased and cemented. Experience tells us that water will filtrate from drilling fluid into the formation and frequently cause hydratable clay minerals to swell when water is absorbed, thus reducing the permeability of the formation. During the cementing of the casing, additional well damage may be expected.

The above mentioned factors have received considerable attention, but another factor just as important is only now receiving much attention; this is the effect of plugging of perforations by drilling fluid at the time the well is perforated. This effect will be discussed at greater length later. These three factors mentioned above should further emphasize the importance of depth of penetration if the productivity of an open hole completion is to be obtained in a cased and perforated completion.

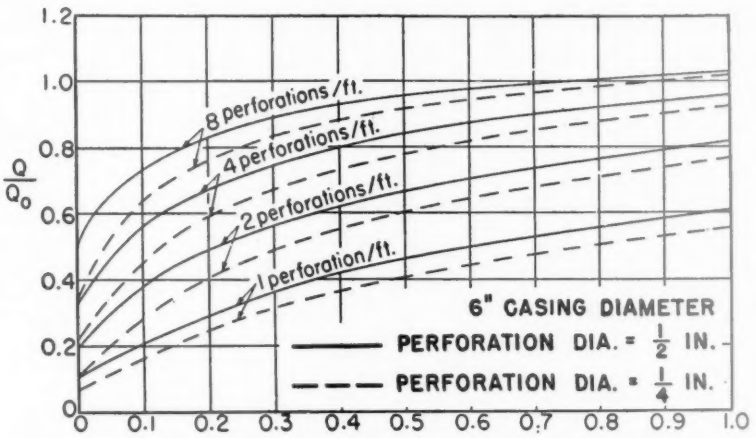


FIG. 4. EFFECT of depth of perforation penetration into formation surrounding casing on well productivity for various perforation densities. Q/Q_o = (Productive capacity of cased and perforated well)/(Productive capacity of uncased well).

From the electrolytic analog studies, we may also evaluate the effect of the number of perforations per foot where penetration is greater than a flush condition. Fig. 5 is the data of the electrolytic analog study re-plotted to better illustrate the effect of the number of holes per foot. It will be seen from this graph that if penetration of one well diameter is obtained, six perforations per foot will exceed the productivity of open hole, while the productivity of flush perforation would only be 44 per cent of the productivity of open hole. This would suggest that where deep penetration, approaching one well diameter in depth may be expected, the number of perforations per foot may be drastically reduced. It will be recalled in Fig. 1 that even 32 perforations per foot did not approach a productivity ratio of one. Thus, we may conclude from these studies that

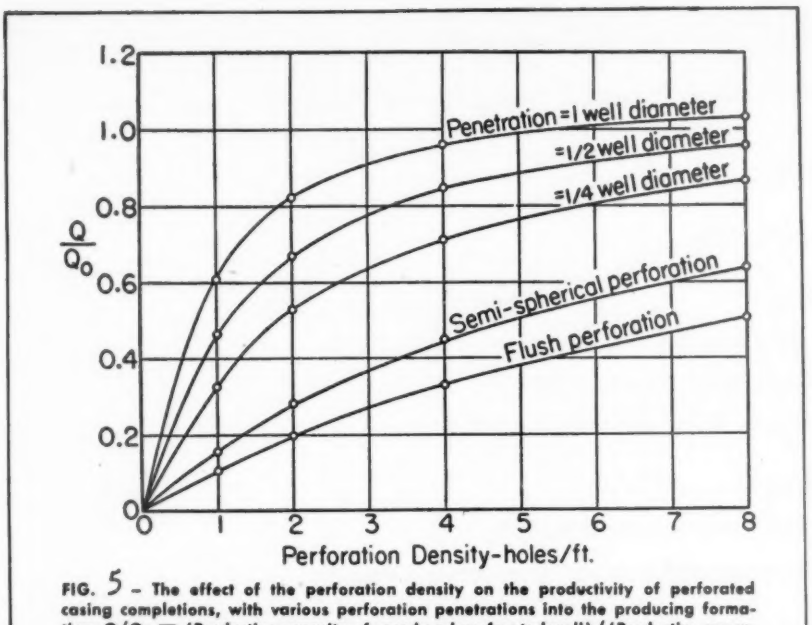


FIG. 5 – The effect of the perforation density on the productivity of perforated casing completions, with various perforation penetrations into the producing formation. Q/Q_0 = (Productive capacity of cased and perforated well) / (Productive capacity of uncased well). Casing diameter = Six inches, Perforation diameter = One-half inch.

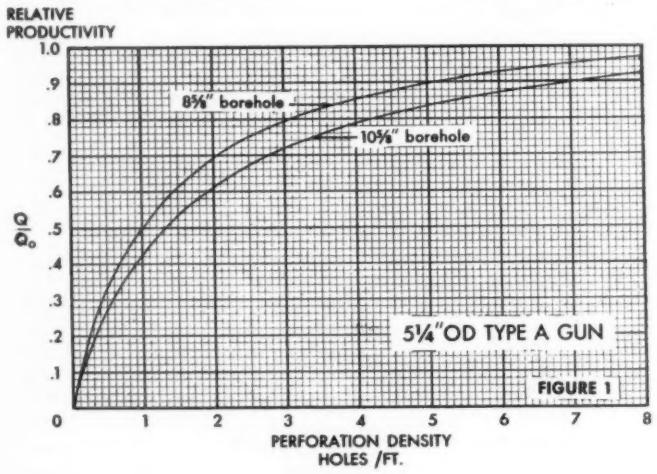
McDowell & Muskat, A.I.M.E. Petroleum Transactions '50.

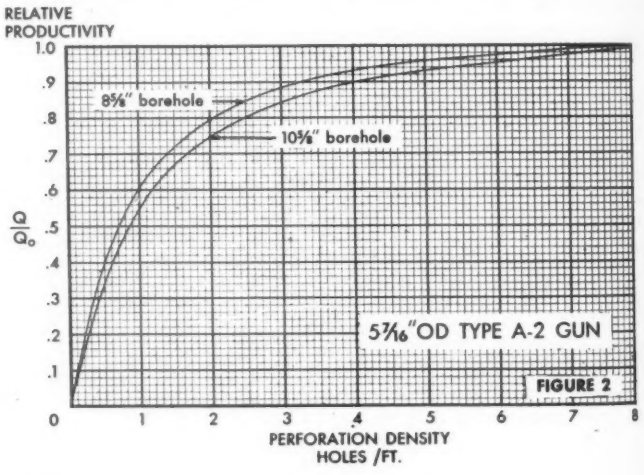
penetration will permit reduction of the shot density when perforation depth approaches one well diameter. Little improvement in productivity is obtained past a shot density of six shots per foot when this depth of penetration may be expected.

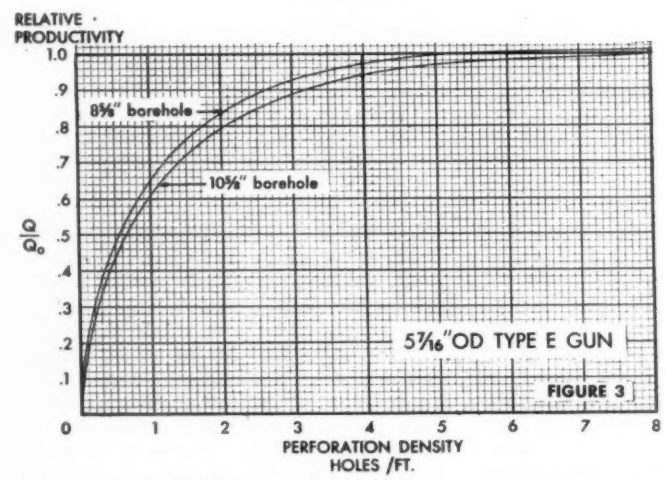
Another factor closely related to depth of penetration and shot density is the diameter of the perforation. By examination of the curves in Fig. 4, an estimate of the effect of the diameter of the perforation may be made. It would appear that under the conditions of the electrolytic analog, the reduction of hole size from ½ in. diameter to ¼ in. diameter would reduce the productivity ratio from three to eight per cent, at one-half well diameter of penetration and from one to five per cent at one well diameter of penetration. This would indicate that some small improvement is obtained by the use of the larger diameter, where depth of penetration and shot density are constant. It would appear that this factor was of no major significance when the diameter of the perforation is between ¼ in. to ½ in. or larger. Other studies have indicated, however, that the shaped charge perforator frequently will produce perforation diameters smaller than ¼ in. particularly at the end of the tapered perforation. It is thought that the reduction of perforation diameter below ¼ in. materially reduces the productivity of a perforated and cased completion. Because of this effect in low density, high porosity formation, the diameter of the perforation may frequently dictate the choice of a perforator capable of producing a larger diameter perforation.

Measurement of Performance of Gun Perforators

In 1951 a paper by Val Forsyth[4] described the measurement of the penetration of bullet perforators and koneshot perforators in the standard target previously described. Using Muskat's







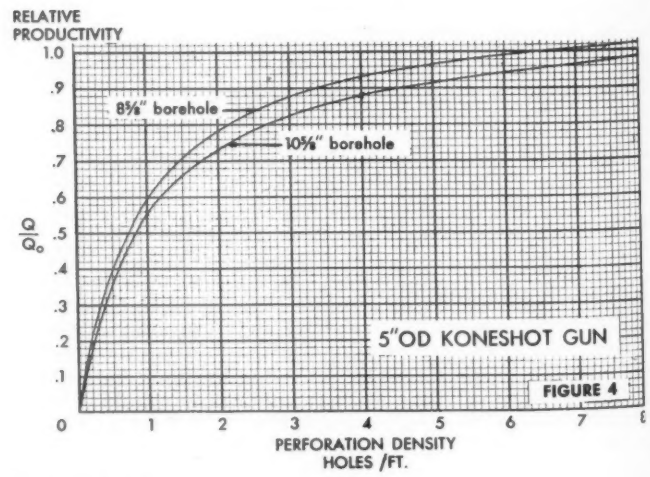


FIG. 6. THEORETICAL relative productivity secured by varying shot density for various guns from penetration results in standard targets.

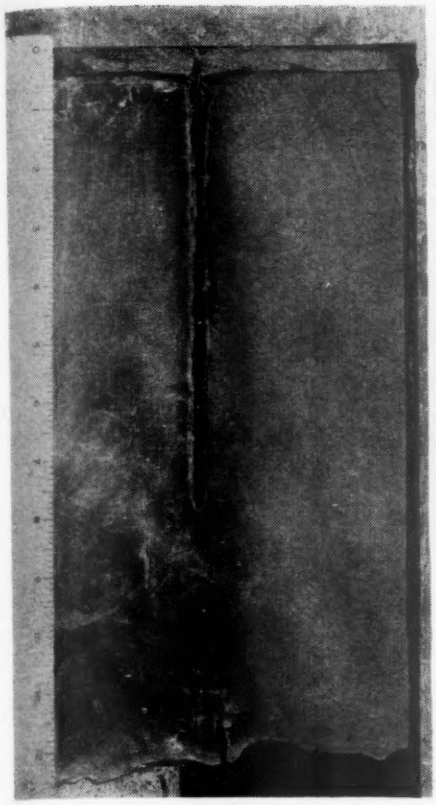


FIG. 7. **STANDARD** target perforated by shape charge perforator.

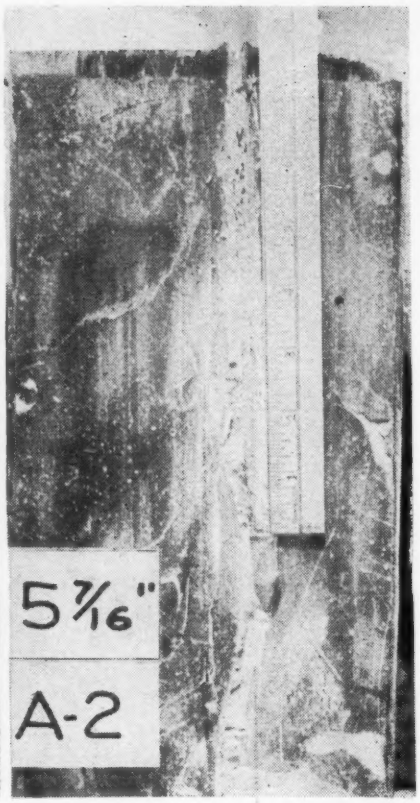


FIG. 7A. **STANDARD** target perforated by bullet perforator.

data as a basis, penetration was expressed in terms of actual inches of penetration into the standard target and Muskat's curves were re-plotted. Fig. 6 shows these data expressed as penetration in the standard target for 7-in. casing cemented in two sizes of well bore — 8⅝ in. well bore and 10⅝ in. well bore, for four gun perforators. In this same paper, depths of penetration for different gun perforators were applied to common oil field sizes of casing and well bore, in order that a comparison may be made between the performance of the various gun perforators in a formation represented by the standard target. These graphs may perhaps be misleading if the resistance of the formation to penetration is not considered. It should be understood that the harder, more consolidated formations offer considerably more resistance to penetration than will the standard target or the less consolidated formations.

Fig. 3 shows the relationship of the penetration ability of bullet perforators and shaped charge perforators in the standard target. It does not, however, reveal the difference in the effect of formation density on the two types of perforators. Bullet perforators are not affected to a great extent by the fluid in the well bore, while shaped charge perforators are affected by the fluid in the well bore. Bullet perforators that show essentially the same penetration ability as the shaped charge perforator in the standard target are affected to a much greater extent by the hardness of the formation; that is to say, as the formation increases in density and hardness, the resistance to bullet penetration increases much more rapidly than in the case of the shaped charge perforator. This effect was investigated and described in a paper by Henry Lewelling[5] in *Petroleum Technology*. The equipment, used in this investigation, is now obsolete bullet perforating equipment, but it did demonstrate that hard limestone cores offered much greater penetration resistance to the bullet perforator. It would be difficult to quantitatively express this difference, but for our purpose, it will suffice to recognize the increased resistance to penetration; thus, one should always take into consideration the hardness of the formation rock when selecting the type of gun perforator. When the formation to be perforated is a hard, dense rock, it would be advisable to select the perforator capable of the greatest penetration, least affected by rock hardness, and it would also be advisable to increase the shot density to make up for the productivity loss due to reduced penetration.

Fracturing by Gun Perforators

The amount of fracturing obtained in a test target or in the formation is difficult to evaluate. The methods of testing the amount of fracturing given by the two types of gun perforators have given conflicting results. Most observations have been made on test shots fired into a test target. It has been difficult to construct a target that will adequately represent a formation subjected to the weight of thousands of feet of over-burden; however, from observations of surface tests, it is indicated that the bullet perforator will provide slightly more fracturing than the shaped charge perforator in the standard target. Fig. 7 shows a picture of the two types of perforators fired into standard targets. The fracturing may easily be observed. Under certain conditions the additional fractures of the bullet perforator may add more adequate drainage channels surrounding the perforation and thereby assist in the production of formation fluid. This type of fracturing might be considered most important when a well is to be acidized and the major requirement is adequate contact with the formation.

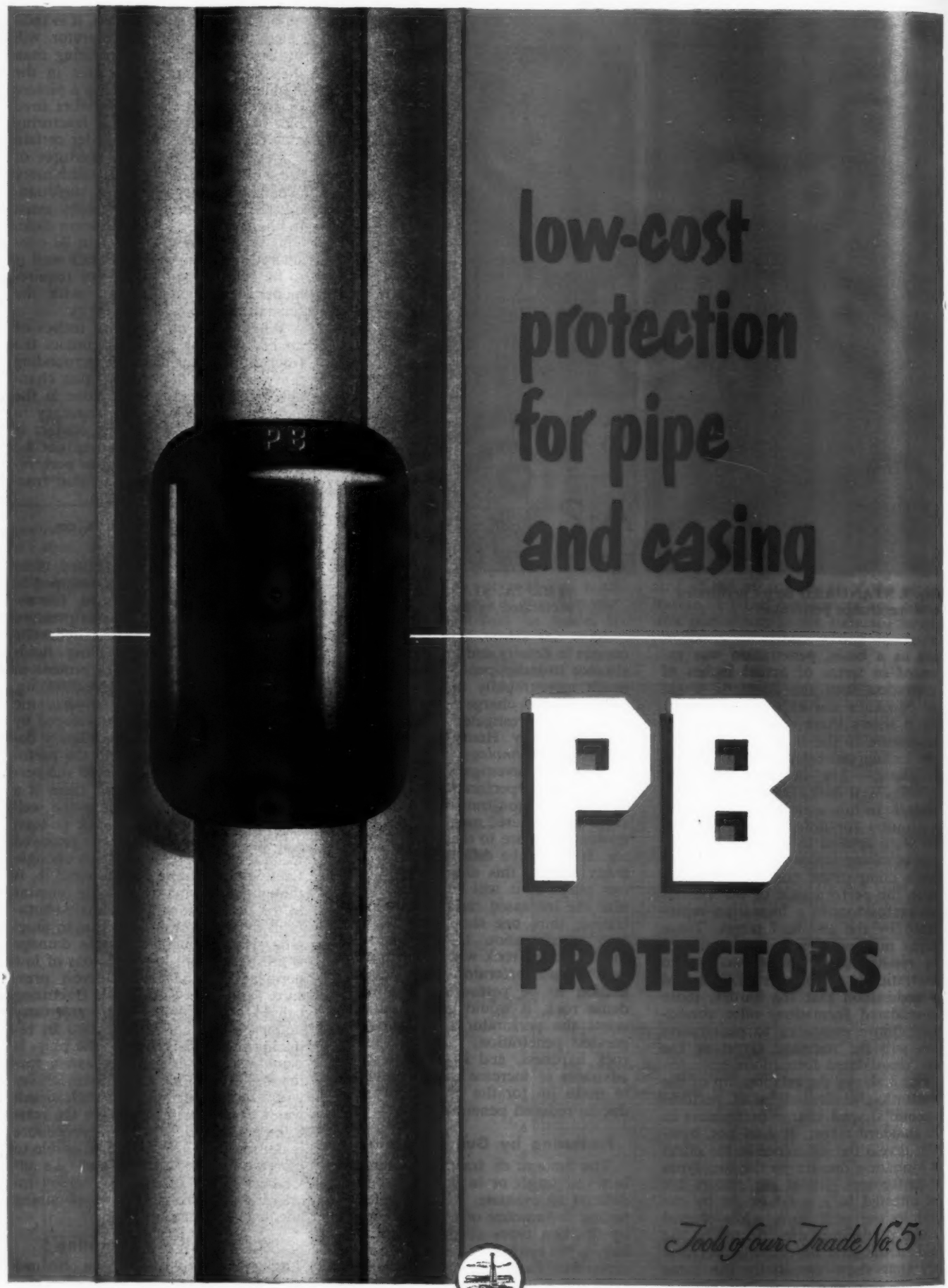
When perforating within inches of an oil/water or a gas/oil contact the fracturing of the cement surrounding the casing could possibly open channels into the water or gas zone as the case may be. Where this accuracy in perforating close to a fluid contact is important, consideration might be given to selection of the gun perforator that would result in the least fracturing of the cement sheath.

Effect of Well Fluids on Perforators

When a gun perforator is fired, there is a tremendous pressure developed in the gun and in the well bore. The results of the dissipation of this pressure is often referred to as the hydraulic hammer effect. When drilling fluids subject to dehydration are present in the well bore at the time of perforating, the combination of the hydrostatic pressure and the pressure developed by the gun perforator, will frequently dehydrate the drilling fluid in the perforation, and effectively plug off the perforation. When this occurs, there is a restriction of fluid flow into the well bore. Under most conditions, at least a portion of the plug will be removed when the rock pressure is high enough. Even under these conditions, it is thought that some of the plug remains in the perforations, and some perforations may be lost entirely due to plugging. It is thought that this damage is most prevalent in formations of low permeability and low reservoir pressure, and the additional fracturing caused by the bullet perforator may under certain conditions assist in reducing the effectiveness of the plug. It would be desirable to perforate a formation which has low permeability with a non-plugging agent such as salt water or oil spotted opposite the zone to be perforated. Where this procedure is not feasible, it would be advisable to increase the shot density, and take advantage of the fracturing, thereby increasing the probability of obtaining adequate productivity.

Combination Perforating

Beneficial results have been obtained by combining the two types of perforators, perforating the shaped charge perforator first and following with the bullet perforator. This procedure has the most value in formations of me-

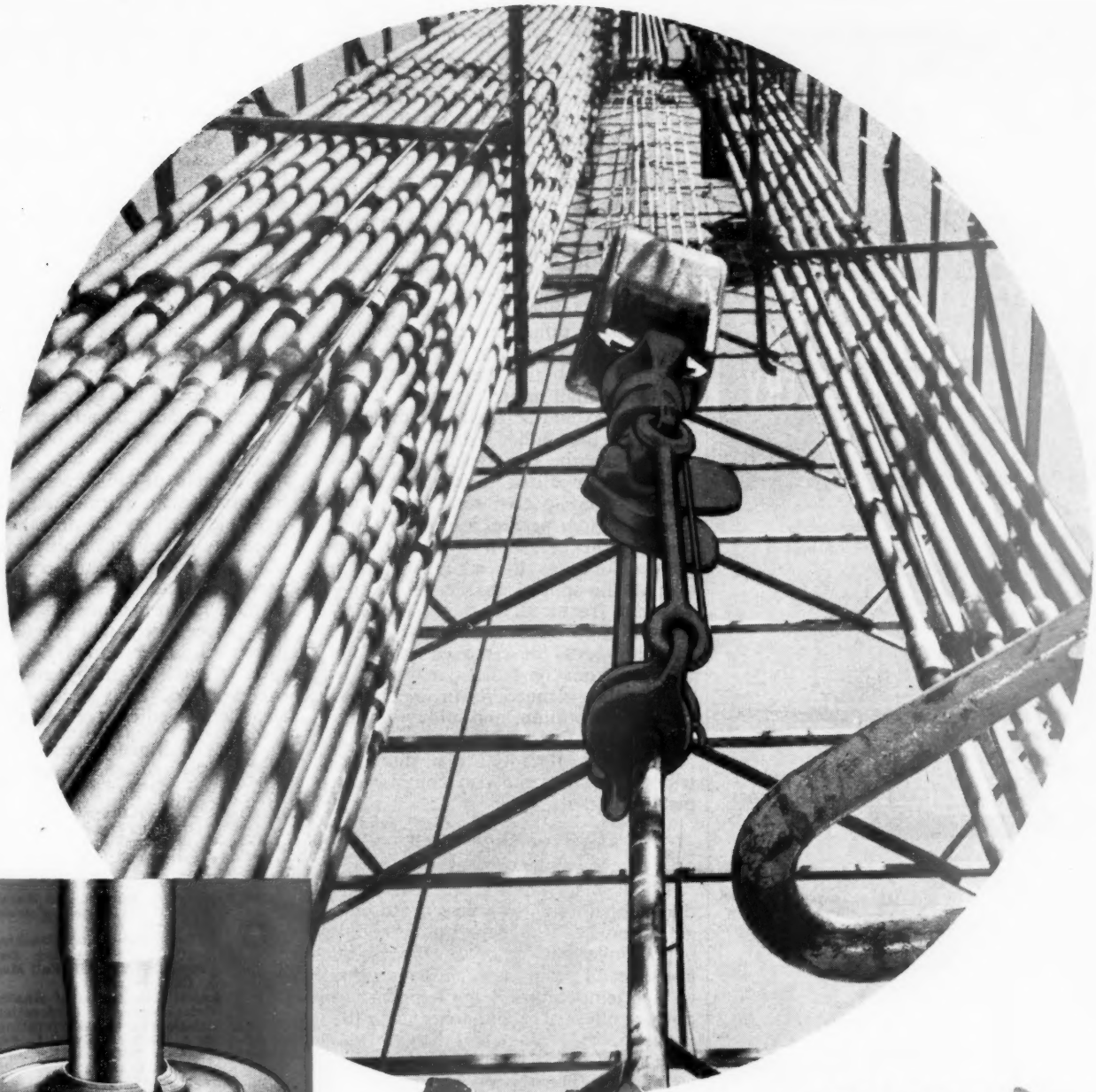


PB OIL FIELD RUBBER SPECIALTIES

BJ PB

Byron Jackson Co. *Since 1872*

LOS ANGELES NEW YORK FORT WORTH HOUSTON



Red Iron at work

FOR OHIO OIL COMPANY ON WORLD'S DEEPEST WELL

BJ tools carried the load . . . a long way, a lot of pipe, but a BJ '4300' Hook, BJ Weldless Links, and a BJ Type BB Elevator had the stuff to handle this record-smashing probe for oil.

PB rubber did it

There were miles of pipe to be wiped . . . in "rubber-eating" oil base mud. *PB Oil-Resistant Pipe Wipers were selected for this rugged work!*

BJ tongs took the "make and break"

2 years of drilling, 4 miles of pipe . . . plus emphasis on coring . . . meant more round trips. These BJ Type B Tongs and BJ Tong Dies stood the test.

ON THE WORLD'S RECORD SETTER OR ON EVERYDAY DRILLING . . .

you're way ahead —with BJ Red

Byron Jackson Co.

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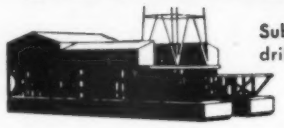
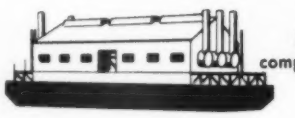


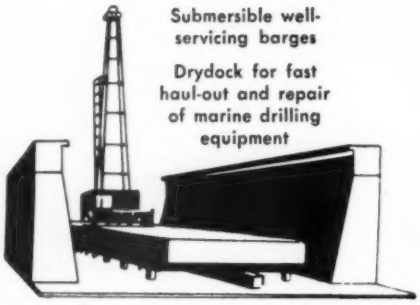
Submersible drilling barges

Tugs



Boiler and compressor barges

Water, oil, and supply barges



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SHIPBUILDING CO.

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dium to low permeability, and it is thought that the combination of the depth of penetration of the shaped charge perforator, with the increased hole diameter and greater fracturing of the bullet perforator combined to give increased productivity. It would be difficult to express the exact reason for the increase in productivity where combination perforating is employed. It is thought that the additional fracturing of the bullet perforator may contribute to the increase in productivity. Tests indicate that both types of perforators compact the formation around the perforation, but it has been observed that the bullet perforator produces small micro fractures. These fractures extend across the compacted zone of the bullet perforation and may, when the two types of perforations occur close together extend across the compacted zone around the shaped charge perforation, thereby increasing the permeability of the compacted zone. As the compacted zone around the shaped charge perforation was not fractured, it is possible that the well fluid would not dehydrate and the plug could be removed when the fracture from the bullet perforator increases the permeability in the shaped charge perforation, and allows formation fluid to force the plug from these perforations. It is felt that this contributes to the results in combination perforating.

Effect of High Well Temperatures

It has been known for some time that temperatures in excess of 260 degrees reduced the penetration ability of the bullet perforator. Further, there is danger of premature detonation due to high temperature. High temperature powder offers a partial solution to the problem, but the penetration of the bullet perforator at high temperature is reduced. The shaped charge perforator is not so limited, in that its penetration is essentially the same at high temperatures as at low temperature. It is necessary to use high temperature components in the shaped charge perforator to assure proper detonation. When these components are used it is possible to use the shaped charge perforator at temperatures up to 315 F.

Conclusion

From the foregoing discussion, perhaps a guide to perforating may be developed.

1. The largest size perforator capable of running in the casing should be selected.

2. Depth of penetration is an important factor to obtaining productivity equal to an open hole completion.

3. Where formation resistance to penetration is low, bullet perforators and shaped charge perforators should obtain essentially the same results with comparable shot density. This may be attributed both to the diameter of the perforation and to the depth of penetration. In formations of this type, little improvement in productivity may be expected with shot densities in excess of four to six holes per foot, with one well diameter of penetration. Where formation resistance to penetration is high, the shaped charge perforator is least reduced in penetration ability, however, the additional formation fracturing may have an equalizing effect. To equal open hole productivities, under these conditions, consideration should be given to increasing shot densities.

4. The diameter of the perforation has a small effect on the productivity. Usually formation conditions, such as sanding up of the well, may dictate the use of a smaller diameter hole. Where heavy crude of low gravity is to be produced, it would be advisable to select a perforator which provides a larger diameter hole.

5. Where possible, wells should be perforated with a non-plugging fluid in the hole such as oil or salt water to eliminate the effect of plugging.

6. The combination of the bullet perforator and the shaped charge perforator in formations of medium to low permeability will frequently produce desirable productivity.

7. In wells of high temperature in excess of 260 F, it is advisable to select the shaped charge perforator.

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2. "The Effect on Well Productivity for Formation Penetration Beyond Perforated Casing," James M. McDowell and Morris Muskat, *Petroleum Technology* (1950), T. P. 2851, Vol. 189.
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4. "Analog Productivity Relationships Applied to Current Gun Perforating Equipment," Val L. Forsyth, A.I.M.E. Fall Meeting, Los Angeles, California.
   "Practical Application of Analog Productivity Relationships to Perforating Productivity Relationships in Perforating Job Design," F. A. Taylor and Val L. Forsyth, *Tomorrow's Tools Today*, 1952, Third Quarter.
5. "Experimental Evaluation of Well Perforation Methods as Applied to Hard Limestone," Henry Lewelling, *Petroleum Technology* (1952), T. P. 332, Vol. 189. ★ ★

Douglas to Explore Peru

Douglas Oil Company of California has acquired operating rights on more than 1000 acres of proved oil land in northern Peru, and an extensive drilling program is being launched this month, President W. G. Krieger announced. Krieger said an agreement has been signed with Compania Petrolera Lobitos, a subsidiary of a British company, Lobitos Oilfields, Ltd., covering all of Lobitos' Continental Shelf concessions in the Lobitos area.

Krieger said that reports from Dean H. Sheldon and Peter H. Gardett, consulting geologists and engineers, indicate that virtually all of the 1000 acres in the Lobitos area is proved oil land. There are at least five producing zones in that area, at depths ranging from 1100 to 7500 ft. The richest of these, the Parinas Zone at 4600 ft, was estimated to contain 15,000 barrels per acre of recoverable oil, with 12 to 20 per cent additional recovery possible through the use of gas injection and repressuring methods.

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DRIVE BUSHING
– BY BAASH-ROSS,
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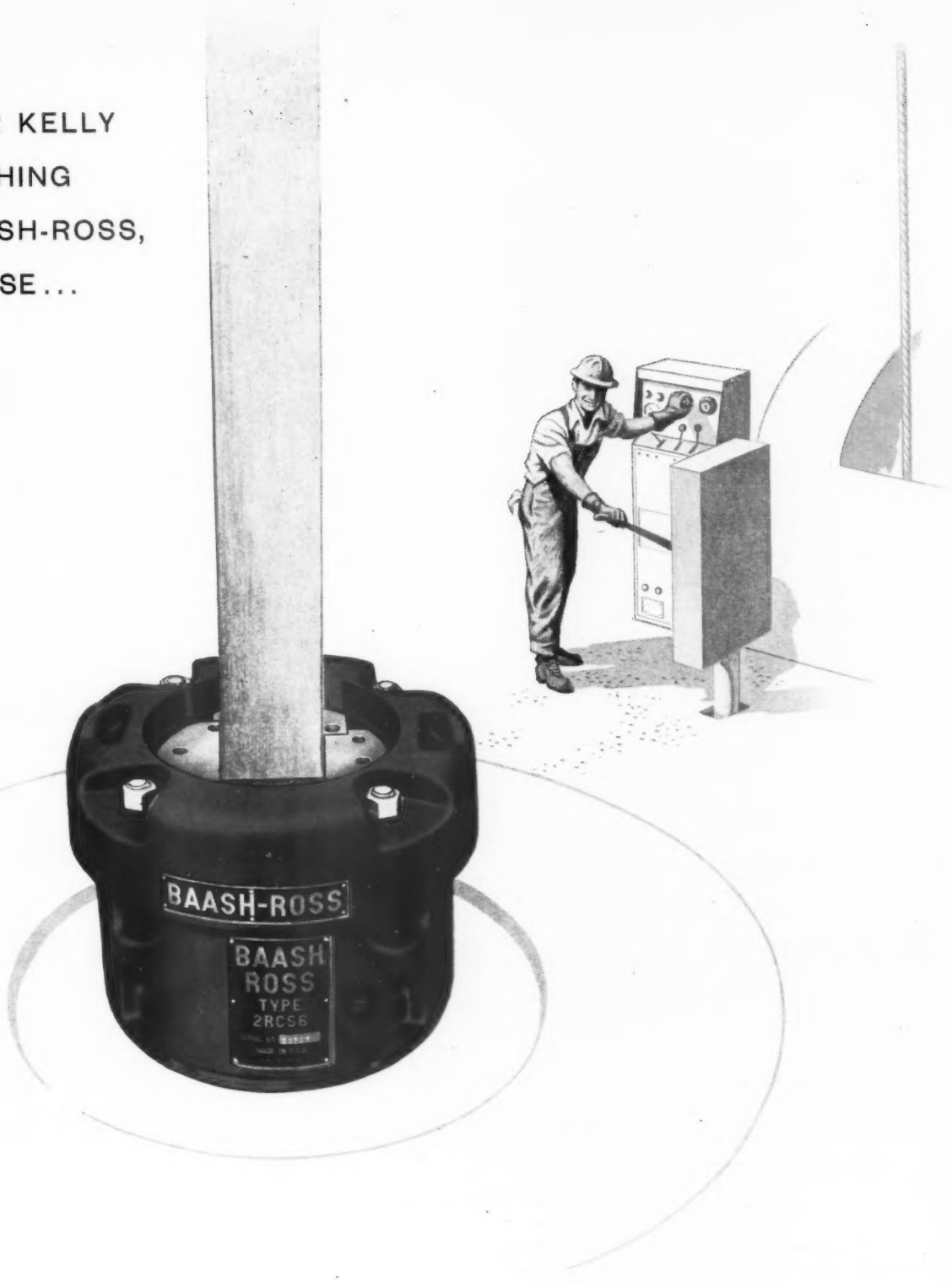

WORLD STANDARD *of the industry!*

BAASH-ROSS TOOL COMPANY *Los Angeles, Houston, Oklahoma City, Odessa, Casper, New York*

CONSTRUCTED in 40 ft of water, this platform serves as base of operations for The Pure Oil Company's four offshore wells in Rollover field.

Bottled Nitrogen Operates

Remote Controlled Master Valves

on Offshore Platforms

Wells can be shut in from safe locations in case of fire or other danger

J. N. MORRELL†

SAFETY is the key word in operation of offshore production platforms.

Being an isolated community that must be self-sufficient for at least a week at a time, every precaution must be taken to insure the safety of the operating personnel and the multi-million dollar installation.

Typical of today's offshore operations is Pure Oil Company's Block 39 field, Vermilion area, Louisiana, which is known as the Rollover field. Here there are four high pressure gas wells producing 30 to 40,000,000 cu ft of gas a day at pressures up to 3000 psi.

The four Christmas trees occupy an area of 25 by 25 ft on the platform, the closeness being dictated by the tremendous costs of offshore construction. This in itself creates a hazard and in an emergency could quickly make the platform untenable.

Each wellhead has a 3-in. 10,000-psi test gate valve, which is operated by a valve control* that is actuated by bottled inert nitrogen gas.

Two banks of nitrogen cylinders are strategically placed; one outside the crew's living quarters, approximately 125 ft east into the prevailing winds and other approximately 50 ft north of wells on pipe rack platform.

Workmen on the platform can quickly reach the nitrogen manifold and by opening the control valve there, the wells can be shut down simultaneously in less than 30 sec, preventing undue damage and reducing danger to personnel as much as possible.

Another control is on the plug valve of the 8-in. submarine pipe line that transports the gas to shore. This valve control goes into operation immediately when the nitrogen valve is opened and it, too, closes within the half minute shut down time.

Should it be desirable, or necessary

†President, E-I-M Company, Inc.

*E-I-M Company type G-2.

EXCLUSIVE

PERFECT "CUSHION"

for FORMATION PIPE AND INSTRUMENTS

JOHNSTON HYDRAULIC TESTER

Eases Drill Stem Test Pressure Release

● In contrast with older drill stem testing equipment which allows sudden pressure release with resulting shock to formation, pipe and instruments, the new Johnston Hydraulic Tester eliminates build up of squeeze pressure when packer is set and slowly releases the pressure below the packer. Opening is in stages requiring three to six minutes.

● This compact and rugged Tester also lessens plugging, damage to wall of the hole and requires less water cushion. You get smoother, more positive interpretation of productivity.

● Positive in operation, the Johnston Hydraulic Tester opens by applying the drill pipe weight — closes by removing the weight.

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SERVICE BRANCHES IN ALL ACTIVE AREAS
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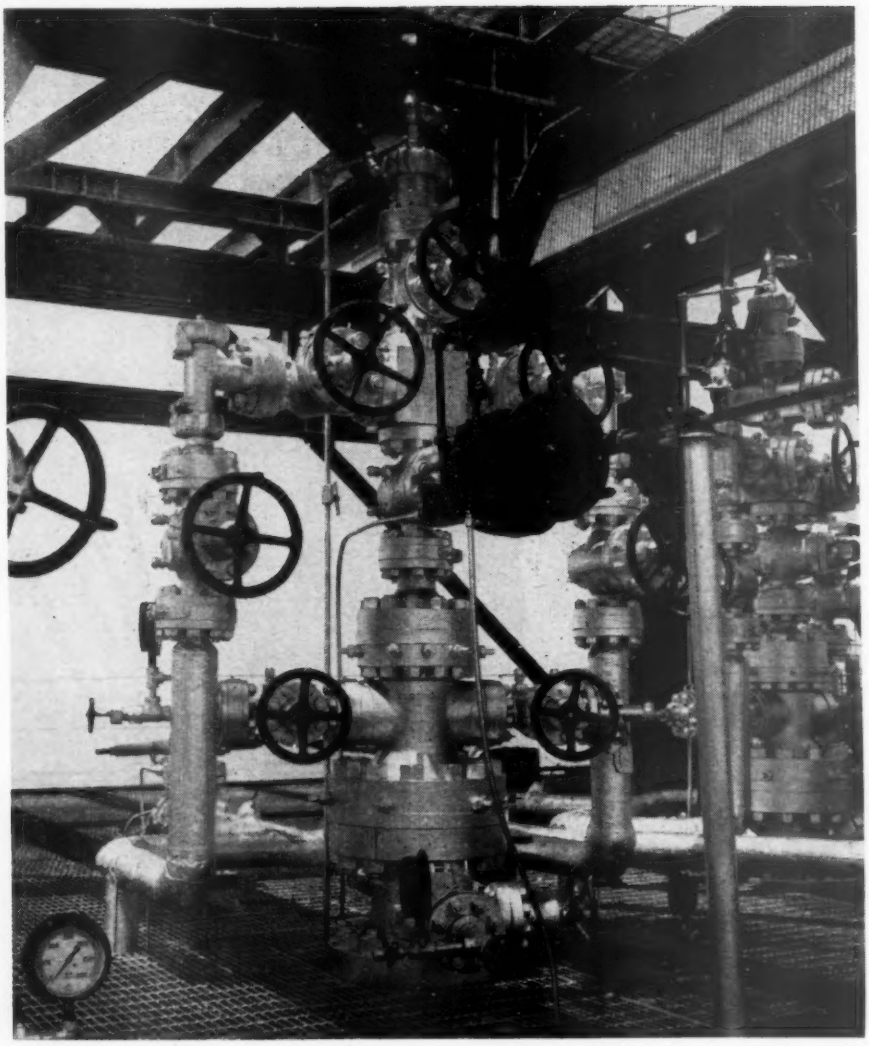
FORMATION AND CASING TESTING — JOHNSTON



MASTER valve can be closed in less than 30 sec by valve control from three remote points.

because of the loss of nitrogen pressure, individual valve controls may be operated by a hand wheel from a remote position protected by a fire wall immediately next to the wellheads. When this hand wheel is used, it requires no more turns than would be necessary for a valve that is not power driven. Power from the hand wheel is transmitted to the valve through a universal joint into the valve stem.

In operational tests the valve controls have proved to be the quickest way of closing the master valves on the wells, and for that reason a closer inspection of the operation will explain how this is accomplished.

This particular type of valve control utilizes a vane type motor that will operate on a minimum pressure of nitrogen of 200 psi and a maximum of 2000 psi. With the opening of the nitrogen manifold valve, the released pressure performs a hammer blow to immediately start the valve opening or closing.

Speed of the vane type motor, or the gas turbine as used on overland pipe lines, is controlled by the correct sizing of piping and valves. All piping and valves are built into the unit so it is self-contained as an integral assembly.

The thrust required to close one of these valves is 9568 lb with a torque of 144 ft-lb at the yoke nut. This is calculated in the following manner:

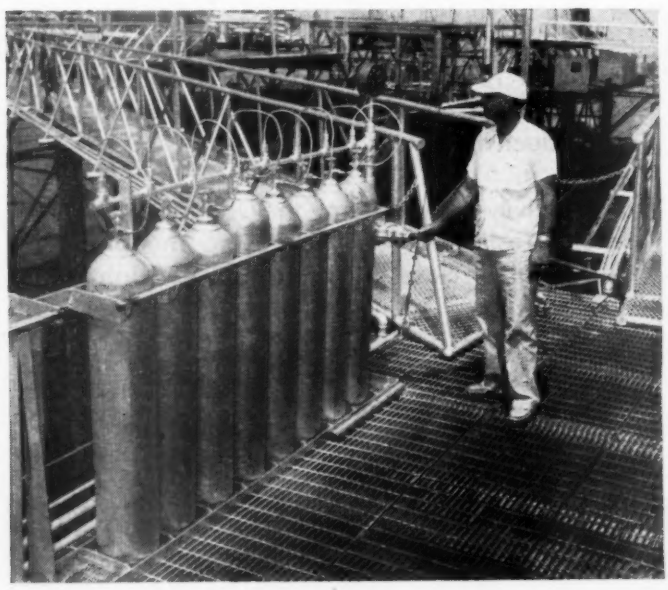
Conditions:

3-in. 10,000-psi test gate valve, stem diameter 1¼ in., 3½ threads per inch. 5000 psi maximum operating differential pressure.

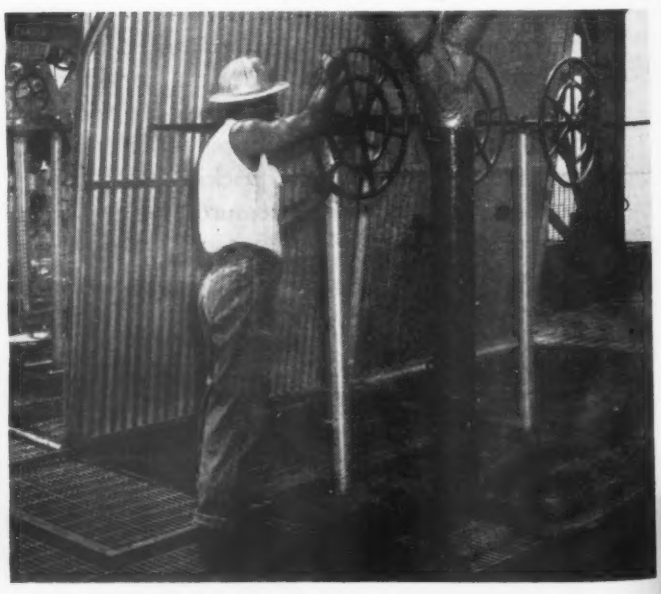
Port area $= 3^2 \times \frac{\pi}{4} = 7.0686$ sq in.

Thrust required to close the valve

CYLINDERS of nitrogen, 125 ft away from the wellheads, are used to remotely close down the master valves on all four wells simultaneously.



HAND operation of valve controls is possible in emergency by turning these wheels. Operator is protected by a firewall between wheels and wellheads.



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equals 7.0686 × 5000 psi × .2 + 2500 lb = 9568 lb

Where:

7.0686 sq in. = clear port area

5000 psi = maximum operating differential pressure

0.2 = coefficient to convert line thrust to stem thrust for this type valve.

2500 lb = stuffingbox friction

Torque required at the yoke nut equals

9568 × 0.015 = 144 ft-lb

Where:

9568 lb = stem thrust

0.015 = screw thread factor for this valve.

Pounds per square inch pressure to valve control motor to operate valve equals:

144 × 2 = 288 psi.

Where:

144 = yoke nut torque, ft-lb.

2 = constant for valve control

By utilizing this type of valve control it is possible to remove the men from the hazardous areas and to protect the equipment when an emergency arises.

This type of valve control can, when the occasion demands, be operated by microwave radio. It is conceivable that in the future offshore operations may be completely remote with this type of system.

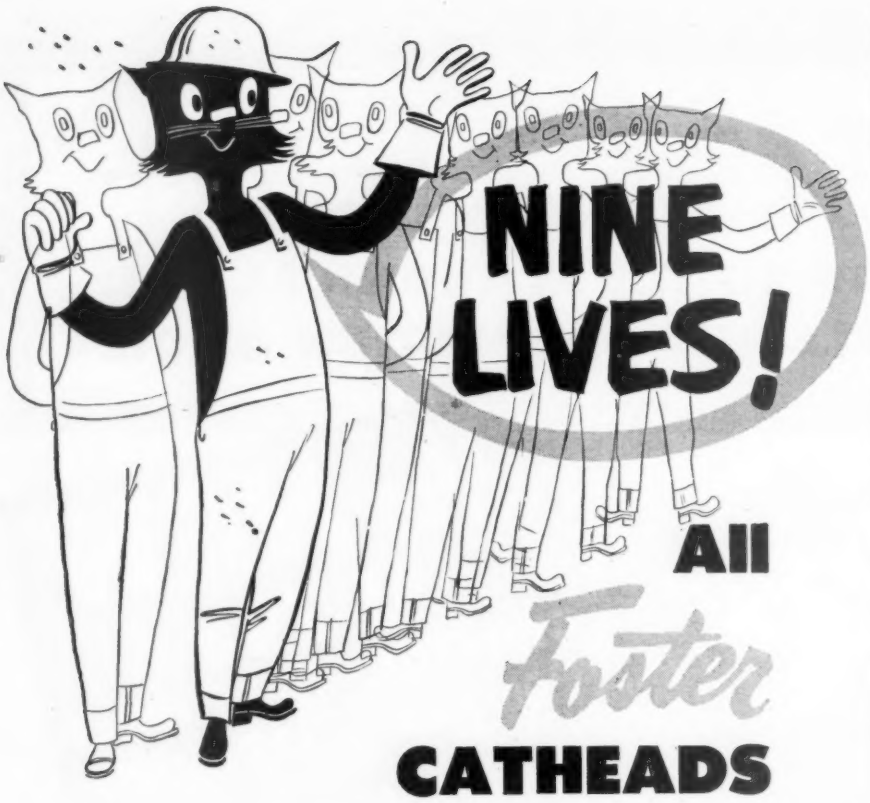
The idea for using valve controls in offshore operations originated from similar protection units that are used extensively in pipe lines. Certain modifications were made for the offshore operation because in most gas compressor stations using this protection the valve control utilizes gas directly from the transmission line.

By throwing a simple cock, situated at any remote point in the station area, the side gates can be closed automatically and the blowdown or vent valves opened simultaneously.

The same equipment is used for gas transmission lines between stations. The controls are usually installed at from 5 to 15-mile intervals and are designed to operate automatically on a predetermined minimum pressure and utilize the gas directly from the damaged line without a reservoir or manifold or they may be operated on a predetermined pressure drop.

The value of automatic valve controls has been recognized by officials of a number of thickly populated states, which are now requiring automatic shut down equipment on pipe lines. ★ ★ ★

There are more than 12,000 independent companies engaged in the production of crude oil in this country. These include oil and gas field contract services, and companies producing crude petroleum, natural gasoline and natural gas.



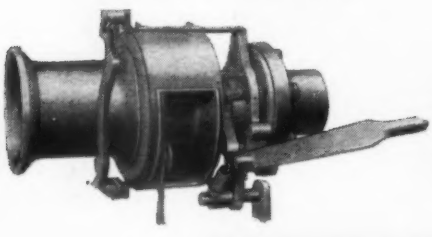
All Foster CATHEADS have that and more!

Foster Catheads are famous throughout the industry for their long service. Many of them have been in operation on well after well for years without repairs of any kind. Heavy duty anti-friction bearings, ample lubrication, low pressure per square inch of clutch face, make this long life, repair-free service possible.

With Foster Spinning Catheads there's no need to hand wrap the spinning line; the line will not foul and wind up; and it can be stopped instantly by releasing the control.

For complete details of these two Foster Catheads see pages 1760 and 1762 of the Composite Catalog.

MIDGET SPINNING CATHEAD



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PLUS FEATURES

Instant engagement without reducing lineshaft speed ● will spin and tong with forked line ● cannot engage accidentally.

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For water well and "blitz" rigs with 3½" (and smaller) drill pipe, choose **Type "C"** – that's me.

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They call me **"H"** for "Husky" because I ate my Manganese and Molybdenum and grew up to be big and strong. I love to wrap around large tight drill collars and make 'em holler "uncle."

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Wemac Field, Andrews County Discovery

Newly found Wolfcamp production south of the Nolley field initiates play in area

MAX LEVIN

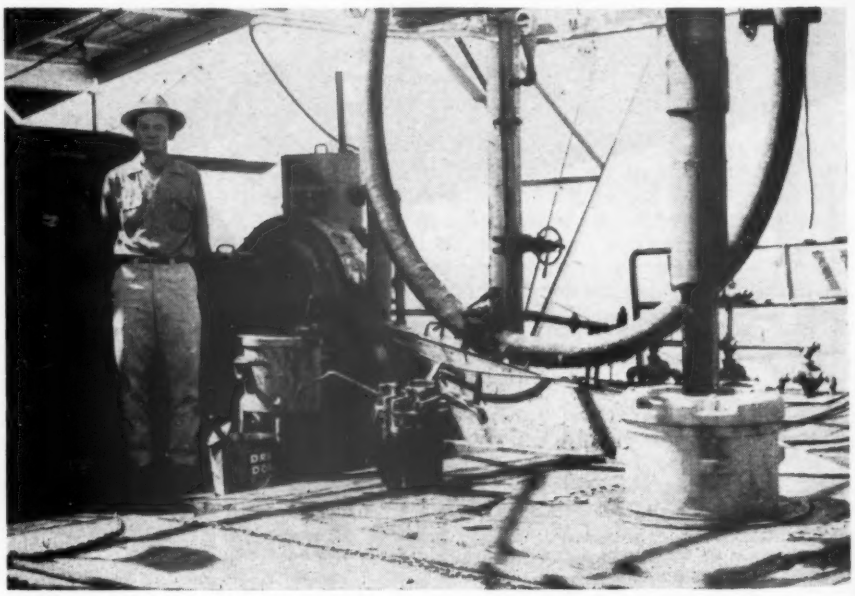
THE Wemac field, a recent significant Wolfcamp discovery, lies in the central portion of Andrews County, Texas (see Fig. 1). The discovery well, Continental Oil Company's No. 1 McCollum and Weibusch, is situated 1980 ft FN & EL, Sec. 24, Blk. A-44, PSL Survey. This discovery is on a block of 3600 acres assembled by Continental. At the present time, Continental has completed three wells in the Wolfcamp formation. Two additional wells are currently drilling; a Wolfcamp step-out to the northwest and a 13,000-ft Ellenburger test, one location south of the discovery well. The original projected depth of the discovery well was to the Ellenburger formation.

Geologically, the well is situated in a transition zone between the Central Basin Platform and the Midland Basin to the east. Following initial subsurface work in the area, a detailed geophysical program using reflection seismograph was undertaken. Drilling began after location was made based on preliminary geological work.

Approximately 700 ft of Wolfcamp has been penetrated in the field. The upper 250 ft of the section is composed of tan, fine crystalline, fossiliferous limestone and dark gray to black shales. Oil found in the Wolfcamp appears to be restricted to zones which occur from 250-550 ft below the top of the Wolfcamp. The pay section is composed generally of a fine crystalline, light gray to tan, fossiliferous limestones with a few thin black and green shale partings. Core data and drill stem tests taken in this interval indicate three different pays in this section. Correlation of the porous zones in the three wells completed to date is rather erratic. The porosity characteristics of the wells in this field are very similar to those in the Nolley field, 16 miles to the north. A typical electric log of the Wolfcamp section encountered in this field is shown in Fig. 2. The microlog shows these porous zones. The porosity averages about 8 per cent in the pay sections and is of the vuggy type. Permeabilities range from 3 md/ft to 100 md/ft. Net pay thicknesses vary from 36 ft to 81 ft. The main water table is tentatively placed at a —5900 ft sub-sea datum.

FIG. 1. INDEX map shows location of Wemac field, Andrews County, Texas.

RAY BOLING, toolpusher, poses on rig.



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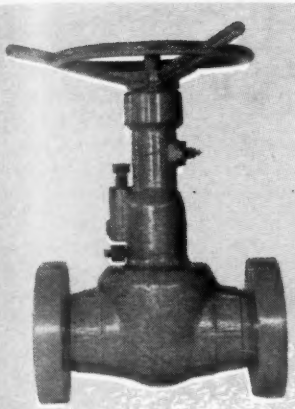
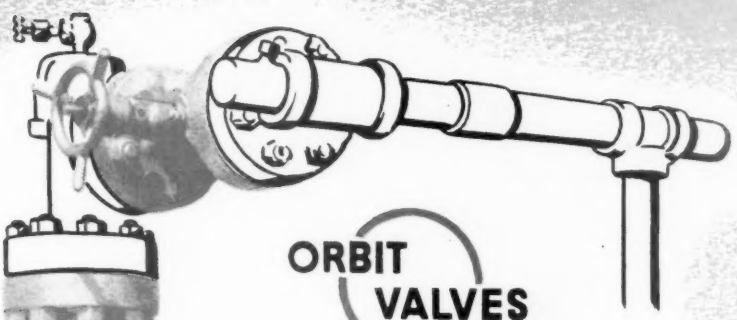
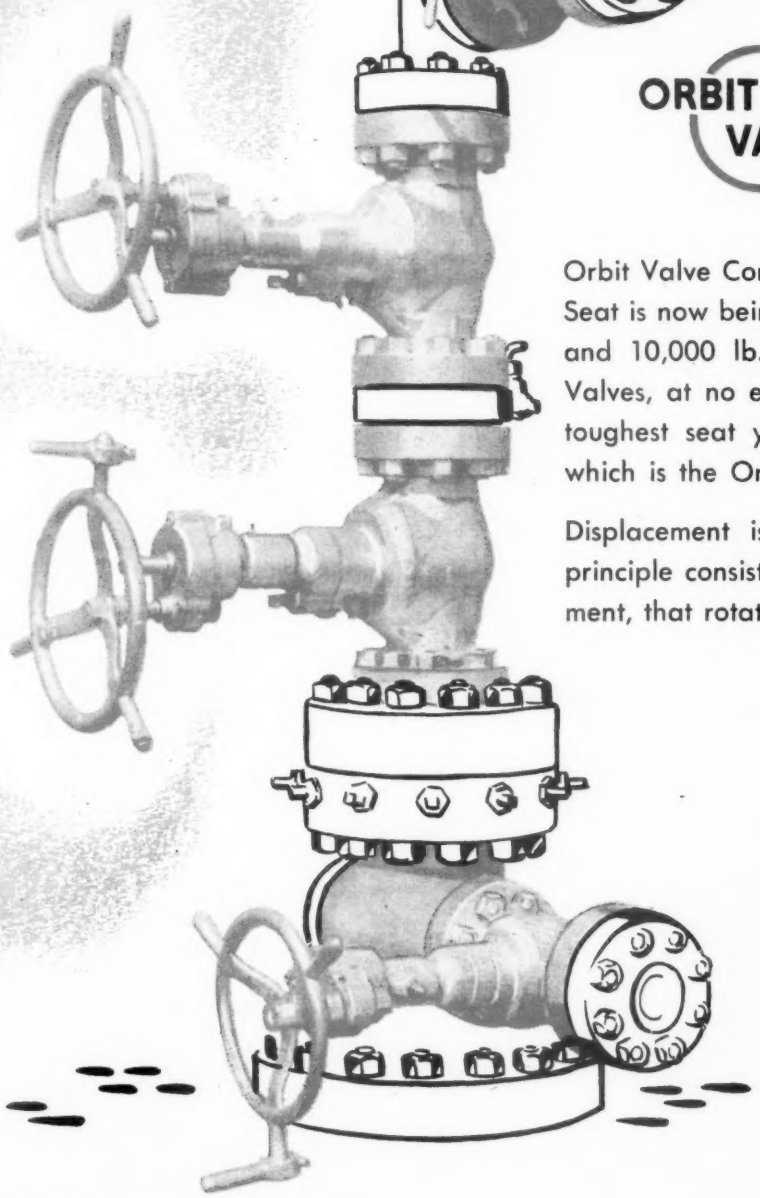




ORBIT VALVES ®



Orbit Valve Company's "Type B" Buna-Stainless Body Seat is now being furnished in all 4,000 lb., 6,000 lb. and 10,000 lb. Test Orbit Forged Steel Production Valves, at no extra cost to the customer. This is the toughest seat yet designed for friction free seating which is the Orbit principle of closure.

Displacement is eliminated through Orbit's seating principle consisting of a core, with a hard faced segment, that rotates instead of being lifted by the stem. The net results from this operation principal besides FRICTION FREE SEATING are; ease of operation and low cost maintenance. All Orbit Forged Steel Production Valves are rising stem type. Available in sizes 1", 1½", 2", 2½", 3" and 4", 500 lb. W.O.G. to and including 5000 lb. W.O.G. Flanged and Screw Ends, A.P.I. specifications.

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ORBIT VALVE COMPANY

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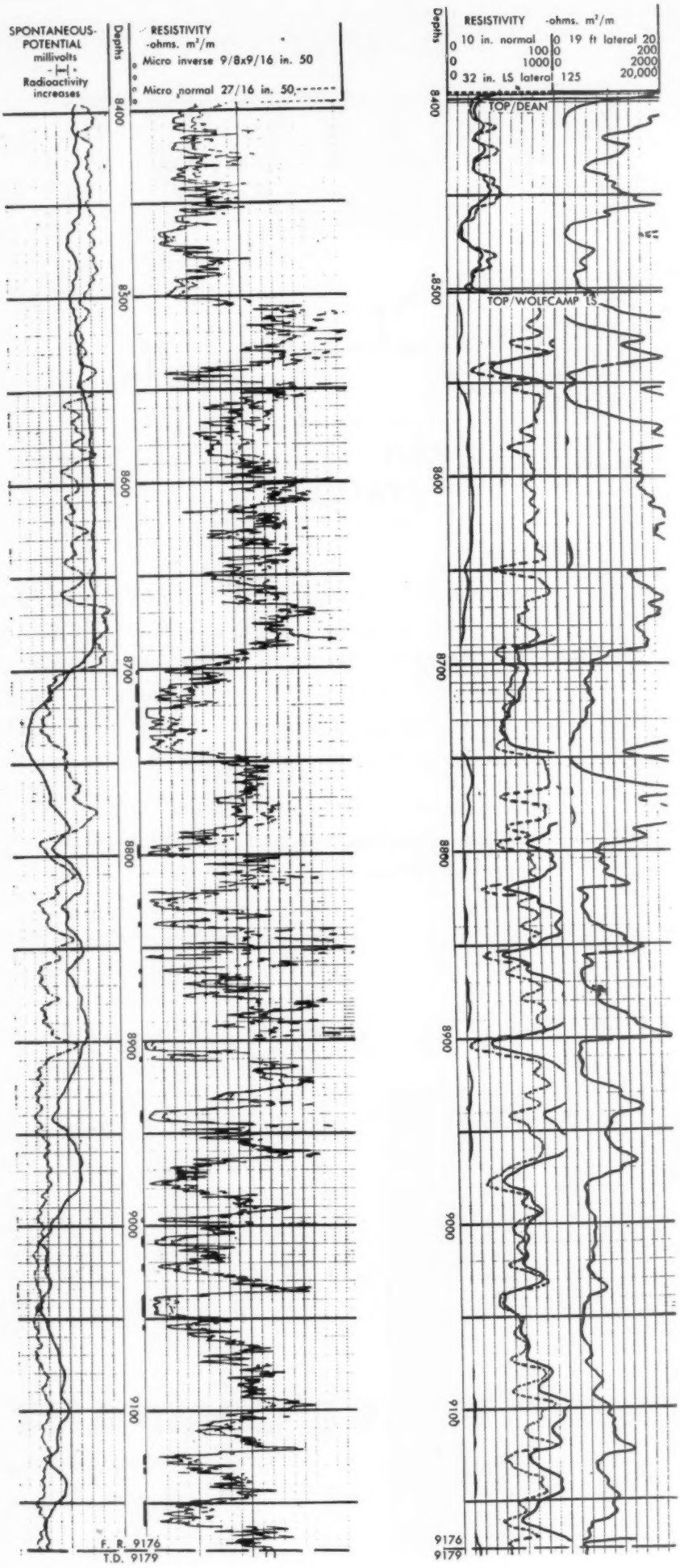

Small amounts of water have been encountered in the upper portions of the pay section.

The discovery well was drilled by Donnell Drilling Company of Odessa, Texas, with an air controlled power rig which has four[1] 325 hp engines driving a 950[2] compound. This unit is rigged with a 136-ft[3] standard derrick of an 800,000-lb capacity. Drilling was under the capable supervision of Ray Boling, toolpusher, from Odessa, Texas.

The initial well was drilled to 9175 ft in 56 days. Drilling and casing procedures were as follows: A 12¼-in. surface hole was drilled to 206 ft using fresh water as a drilling fluid. This hole was then reamed to 17½ in. and 13⅜ in. surface casing cemented with 225 sacks of regular cement. A saturated salt base mud was used for drilling a 12¼-in. hole to 4840 ft. At this depth, 9⅝-in. intermediate casing was set with 2250 sacks of cement containing 4 per cent gel, 100 sacks neat cement, 110 sacks of Stratocrete mixed with the remaining amount of regular cement. The remainder of the footage to 9175 ft was drilled with an 8¼-in. bit using a drilling mud composed of soda ash and aquagel. At total depth, 7-in. casing was set with 800 sacks of cement made up of gel, neat cement and regular cement.

Eight drill stem tests were taken in the Continental No. 1 McCollum and Weibusch. Shows were tested in the San Andres, Clearfork and uppermost Wolfcamp formations and were found to be non-productive. Four tests indicating production were taken in the Wolfcamp, however. The intervals tested and their results are as follows:

DST No. 4 (8696-8716) Tool open 2:00 hr, good blow air throughout, no gas—recovered 1000 ft water blanket + 420 ft HO&GCM. FP 375 lb, BHP (15 min shut in) 700 lb.

DST No. 5 (8690-8792) Tool open 3:05 hr, gas to surface in 8 min, fluid in 1 hr and 25 min. Flowed 26 BOPH; IFP 525 lb, FFP 1325 lb, BHP (15 min S.I.) 3600 lb.

DST No. 6 (8792-8876) Tool open 2:30 hr, gas to surface in 8 min, recovered 1000 ft HO&GCM + 4022 ft free oil. IFP 200 lb, FFP 600 lb, BHP (15 min S.I.) 2550 lb.

DST No. 7 (8876-8978) Tool open 3:30 hr, gas to surface in 7 min, fluid in 1 hr and 52 min. Flowed 16 BOPH; IFP 300 lb; FFP 1050 lb; BHP (15 min S.I.) 2475 lb.

DST No. 8 (8978-9078) Tool open 1:30 hr, lt blow air T.O. Recovered 90 ft HGCM + 2140 ft salt water. FP 400 lb-1000 lb, BHP 3355 lb (15 min S.I.).

The Continental No. 1 McCollum

[1]LRO Waukesha.
[2]Bethlehem.
[3]L. C. Moore.

FIG. 2. Typical electric log and microlog of Wolfcamp section.

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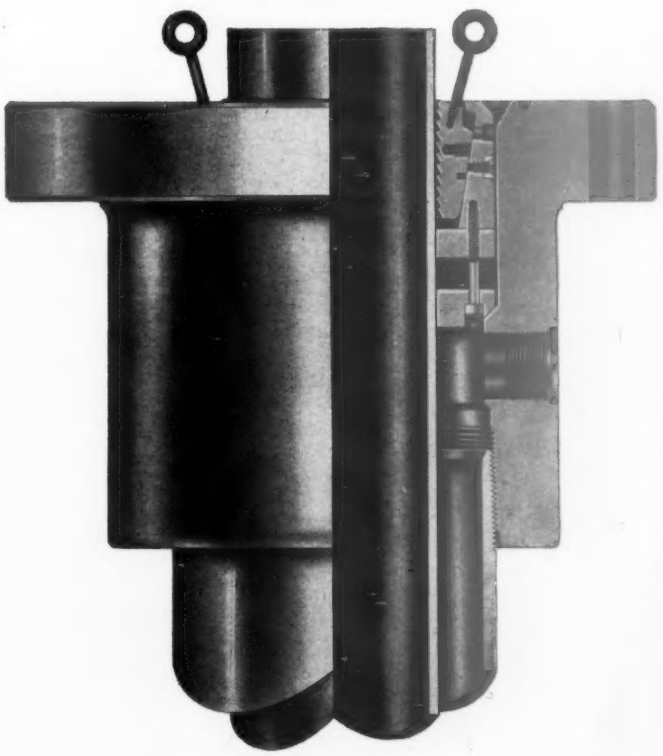

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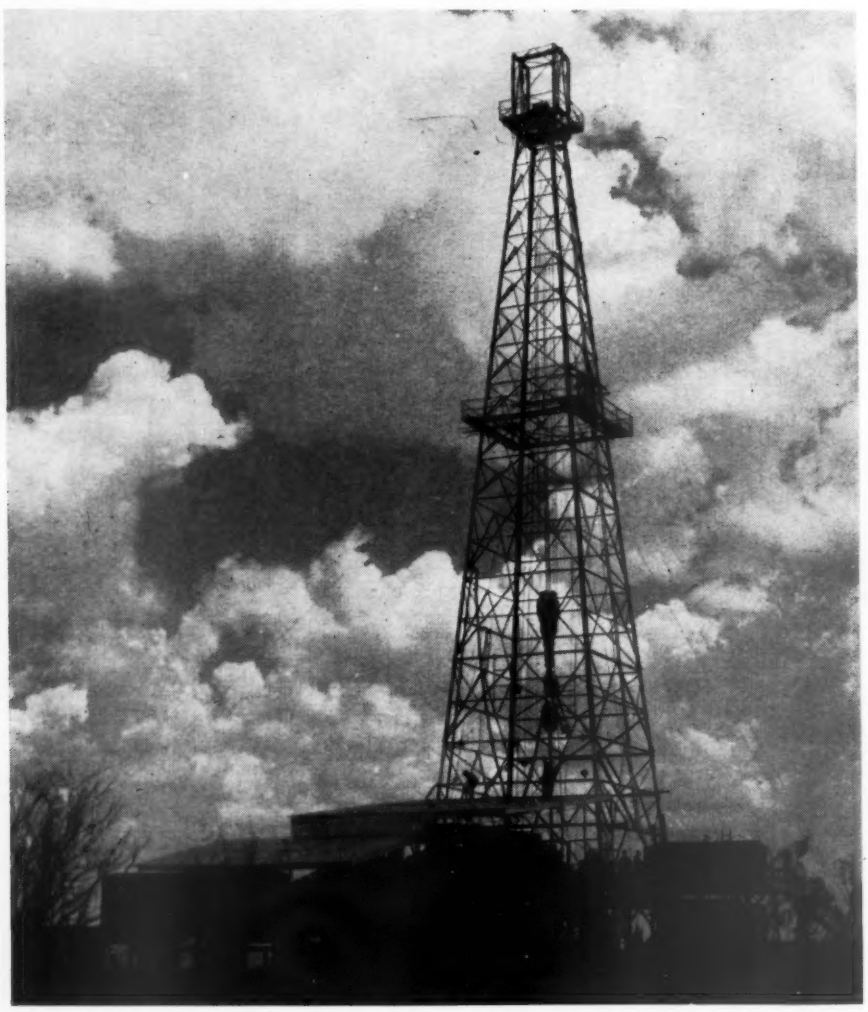
The Author

Max Levin

Max Levin, Continental Oil Company, was graduated from the University of Texas in February, 1947, with a BS degree in geology. Following graduation, he was employed in seismic exploration in the Gulf Coast area for 2½ years. He returned to the University of Texas in 1949 to procure his Master's degree in geology. After graduation in 1951 he joined Continental Oil in Midland, Texas, where he is presently employed.

MAX LEVIN, geologist; O. L. Stevenson, driller; J. A. Young, derrickman; Lee M. Kilmer, motorman; C. C. Leifeste, roughneck; and J. M. Montgomery, roughneck are shown on rig floor.



DONNELL Drilling Company rig is on McCollum and Weibusch lease.

and Weibusch was completed as a new discovery May 10, 1953. Casing was perforated with 4 jet shots per foot opposite the following intervals: 8708-8750 ft; 8768-8778 ft; 8794-8810 ft; 8826-8836 ft; 8840-8846 ft; 8864-8872 ft; and 8924-8950 ft. Perforations were acidized with 2200 gal. The well flowed 390 bbl of 42.6 gravity oil, no water, in 6 hr through a 1-in. choke for a calculated daily rate of 1560 bbl of oil. The gas-oil ratio was 477-1.

Continental's second well in the field was completed for a calculated daily flowing potential of 1244 bbl of oil. The potential was based on an actual 6 hour flow of 311 bbl through a 1-in. choke from perforations at 8917-8927 ft and 8988-9014 ft.

Continental's No. 3 McCollum and Weibusch was completed on the pump for a daily potential of 113 bbl of oil and 126 bbl water from perforations at 8857-8868 ft; 8883-8890 ft; 8898-8920 ft.

Oil produced is being taken by Magnolia Pipe Line Company.

Discovery of the Wemac field has initiated a Wolfcamp play in this area. It is hoped that the data presented in this paper will benefit other operators in the area. * * *

Problem facing one oil company was what to do with oil-soaked sand after useable quantities of oil had been separated from it. The solution was ideal. It was used to surface lease roads on which traffic was too light to justify paving with asphalt!

Domestic Substitutes for

Quebracho in Oilwell Drilling Fluids

Results of laboratory evaluation of fifteen materials found to have considerable merit

W. HODGE CARAWAY

FOR its supply of quebracho for use in conditioning oil-well drilling fluids and in tanning leather, the United States relies wholly on importations from Argentina and Paraguay, as there is no domestic supply of this material. According to the U. S. Department of Commerce,[1] 138,058 short tons of quebracho extract were imported into the United States in 1952.

In December 1948 the Munitions Board, of the Department of Defense, called attention to the possibility that in a national emergency importations of quebracho might be cut off or drastically reduced and cause a serious shortage. Consequently, the board suggested that a study be made to determine the relative merits and quantitative availability of various substitutes for quebracho in the oil-well drilling industry. Such a study already was being made in the leather industry. Accordingly the Bureau of Mines working in cooperation with the Regional Research Laboratories of the Department of Agriculture and many industrial organizations, began a search to explore the possibilties of using domestic substitutes for quebracho in treating oil-well drilling fluids. Likewise, at the instigation of the Munitions Board, the National Petroleum Council appointed a study committee to review the technical requirements of the industry with respect to quebracho and the possible use of substitutes.

As a matter of national security the National Production Authority issued Order M-57 in April 1951 authorizing the stockpiling of quebracho and limiting its use in oil-well drilling to 60 per cent of the base-period consumption. As suitable substitutes were being developed, it was assumed that they would adequately supplement the reduced supply of quebracho resulting from the reduction in importations.

Although good progress has been made in utilizing substitutes, none has been found that can effectively meet all drilling conditions. Furthermore, the availability of many effective substitutes falls far short of meeting requirements. Consequently, early in 1952, with the demand for quebracho increasing, the National Production Authority in response to recommendations of the Petroleum Administration for Defense and the National Petroleum Council removed the percentage restriction on the use of quebracho in the drilling industry.

The Author

W. Hodge Caraway, petroleum engineer, U. S. Bureau of Mines, was graduated from Rice Institute with a BS in chemical engineering. After graduation he worked for the United Gas Company and the engineer board, U. S. War Department before joining the Bureau of Mines. For the past several years he has been engaged in a study of the preparation and control of drilling fluids.

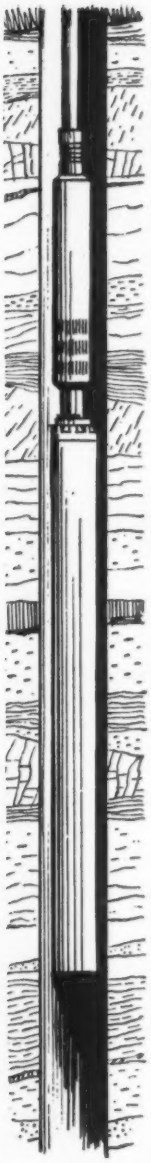
In its search for quebracho substitutes the Bureau of Mines has tested 70 materials comprising both natural and synthetic substances ranging from chemically processed "chicken feathers" to South African "wattle bark" extract. Most of the natural materials were agricultural and wood by-products, and most of the synthetic materials were of the detergent type. Although none of the materials tested was found to be equivalent to quebracho in effectiveness, especially on a pound-for-pound basis, some materials approached quebracho in controlling the properties of three drilling fluids under most conditions. This paper presents the results of laboratory evaluation tests showing the relative merits of fifteen substitute materials as to their effect on the viscosity and filter properties of three drilling fluids, their resistance to sodium chloride contamination, and to high-temperature deterioration. These fifteen products were selected as the most promising of the 70 materials tested. In addition, the paper includes graphical data comparing the effectiveness of the materials believed to be of the most practical interest. Included also is a discussion of the availability of some of the more effective substitutes.

Description of Evaluation Tests

Three clay-water drilling fluids, prepared from Ventura Gray clay (Ventura County, California), Frazier Mountain clay (Ventura County, California), and Alvin (Brazoria County, Texas,) shale were treated with the various substitute materials to determine their effect on the viscosity and filter properties of the muds.[2] Ventura Gray clay was used in these tests because the behavior of drilling muds prepared from this clay is comparable to "poor" California hole muds which require improvement. Frazier Mountain clay was used because the viscosity and filter properties of a mud containing this clay are responsive to quebracho-caustic solutions. Its properties are similar to those of many California hole muds. Alvin shale hole mud was used because it is typical of many hole muds in the Gulf Coast area. When drilling through thick sections of this shale large quantities of the shale are dispersed in the drilling fluid.

Frazier Mountain drilling fluid was used to determine the resistance of the treating materials to sodium chloride contamination and to high-temperature deterioration. The effect of sodium chloride contamination was determined in a series of tests in which the viscosity of the pretreated Frazier Mountain clay drilling fluid was measured after each addition of salt water. In drilling many deep wells the high temperature of the mud causes most treating materials to lose their effectiveness as viscosity reducers. To determine the effect of heat on quebracho and various possible subsitutes a series of tests was run in which the treated Frazier Mountain clay mud samples were maintained at 200 F for periods of 3 to 6 hours, and the viscosity and the filter properties were determined before and after heating.

Except for the tetra sodium pyrophosphate, the treating materials were dissolved in sodium hydroxide solutions, as is common practice in adding



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quebracho to a drilling fluid. The weight ratio of the sodium hydroxide to each of the treating materials used in these tests is shown in Tables 2 and 3. Since some of the materials already contained sodium hydroxide or appreciable quantities of insoluble material, the ratio of sodium hydroxide to treating material was chosen so that the ratio of total sodium hydroxide to soluble treating material would be ½ to 1. Some of the materials, however, contained an unknown quantity of sodium hydroxide, and as the effectiveness of a given material often depends on the ratio of sodium hydroxide to soluble treating material, an accurate comparison with quebracho on a weight basis was not always possible. Because of a wide difference in costs of these materials, comparison on a weight basis is not as significant as comparison on a cost basis.

In these tests no record of the pH was tabulated because it is believed that the results obtained indicate that each of the more practical substitutes should be studied over a wide range of pH values. Although a complete evaluation of any one of the substitutes necessitates tests over a wide range of pH, it is believed that the results presented in this report are significant of the performance that may be expected

TABLE 1. Qualitative evaluation of Quebracho and Quebracho substitutes.

Sample number	Materials	Effectiveness in controlling viscosity and filter rate of Ventura Gray (Calif.) clay, Frazier Mt. (Calif.) clay, and Alvin (Tex.) shale muds[1]	Effectiveness in resisting salt contamination in Frazier Mt. clay mud[1]	Effectiveness in resisting heat deterioration in Frazier Mt. clay mud, T=200 F	Estimated potential quantity of materials easily accessible	Limitations to possible use
1.	Quebracho	Satisfactory	Satisfactory	Satisfactory	.....	Not a domestic product
2.	Lignite product No. 1	Satisfactory	Satisfactory	Slightly inferior	Large	.....
3.	Wine pomace	Slightly inferior	Partially satisfactory	Satisfactory	Large	.....
4.	Douglas fir bark product No. 1	Satisfactory	Unsatisfactory	Unsatisfactory	Large	.....
5.	Tetra sodium pyrophosphate	Satisfactory	Partially satisfactory	Partially satisfactory	Medium	Supply critical in emergencies
6.	Lignite product No. 2	Satisfactory	Partially satisfactory	Partially satisfactory	Medium	.....
7.	Hemlock bark	Satisfactory	Partially satisfactory	Unsatisfactory	Medium	.....
8.	Redwood bark product	Satisfactory	Partially satisfactory	Unsatisfactory	Medium	.....
9.	Douglas fir bark product No. 2	Satisfactory	Unsatisfactory	Unsatisfactory	Large	.....
10.	Calcium ligno sulfonate	Satisfactory	Unsatisfactory	Unsatisfactory	Large	.....
11.	Tannery waste product	Slightly inferior	Unsatisfactory	Slightly inferior	Medium	Very bad odor
12.	Wattle bark extract	Satisfactory	Satisfactory	Slightly inferior	.....	Not a domestic substance
13.	Chestnut woodextract	Satisfactory	.....	.....	Small	Limited supply
14.	Pecan shell extract	Satisfactory	.....	.....	Small	Limited supply
15.	Lignite product quebracho blend	Satisfactory	Unsatisfactory	Satisfactory	Large	Large quebracho content
16.	Canaigre root	Partially satisfactory	.....	.....	Small	Limited supply, mediocre perform

[1] Satisfactory — Effectiveness is reasonably close to that of quebracho.
Slightly inferior — Effectiveness is appreciably inferior to that of quebracho, but still sufficient for control of the drilling fluids under most conditions.
Partially satisfactory — Effectiveness is appreciably inferior to that of quebracho, but still sufficient for control of the drilling fluids under most conditions.
Unsatisfactory — Any improvement in the properties of the drilling fluid is small compared to that obtained with quebracho.

TABLE 2. Effect of Sodium Chloride on Frazier Mt. (Calif) clay-water mud treated with Quebracho and Quebracho substitutes.

Sample number	Pretreatment material added	Quantity added, lb per bbl: *	Quantity added, lb per bbl: NaCl	Filtrate volume, ml. Time, minutes: 0	30	60	Temp. F	Stormer viscosity, 68 F, 600 rpm driving weight, grams: NaCl added, lb per bbl: 0	0.5	0.9	1.8	3.5	5.1	6.3	Ratio[1] NaOH to pretreatment additive
1a.	Quebracho	3.5	6.3	0*	25.0	35.0	72	165	175	185	185	215	420	...	¼
1b.	Quebracho	3.5	6.3	0	17.4	23.6	72	130	130	130	140	190	310	480	½
2a.	Lignite product No. 1	3.5	6.3	0	25.6	35.8	72	135	140	160	200	350	410	460	¾
2b.	Lignite product No. 1	3.5	6.3	0	15.0	22.0	72	125	130	130	150	200	250	370	½
3.	Wine pomace	[2]4.5	6.3	0	20.5	29.8	72	140	150	170	200	280	480	700	¼
4.	Douglas fir bark product No. 1	[2]4.5	6.3	0	23.0	32.0	72	150	220	250	310	540	820	820	¼
5.	Tetra sodium pyrophosphate	2	6.3	0	17.0	25.0	72	100	100	100	135	310	430	420	None
6.	Lignite product No. 2	3.5	6.3	0	27.4	36.0	72	145	180	200	275	510	570	520	¼
7.	Hemlock bark	[2]4.5	6.3	0	25.0	35.0	72	130	140	150	175	255	425	450	¼
8.	Redwood bark product	3.5	6.3	0	18.0	27.0	72	140	...	175	210	290	490	815	¼
9.	Douglas fir bark product No. 2	3.5	5.1	0	18.0	25.0	72	140	180	210	310	480	920	...	¼
10.	Calcium ligno-sulfonate	3.5	3.5	0	14.0	19.0	72	150	...	540	580	740	...	...	¼
11.	Tannery waste product	3.5	3.5	0	18.5	25.0	72	150	...	240	350	590	...	...	½
12.	Wattle bark extract	3.5	6.3	0	17.0	24.0	72	140	130	140	...	150	250	320	½
13.	Chestnut wood extract	...	...	.	.....	.....	..	...	...	...	...	...	...	...	..
14.	Pecan shell extract	...	...	.	.....	.....	..	...	...	...	...	...	...	...	..
15.	Lignite product, quebracho blend	3.5	6.3	0	20.0	30.0	72	145	...	260	330	500	...	1000	½
16.	Canaigre root	...	...	.	.....	.....	..	...	...	...	...	...	...	...	..

[1] As some of the products contained either NaOH or appreciable quantities of inert material, different ratios of NaOH to treating material were necessary to keep the ratio of the NaOH to the soluble material between ½ and 1.
[2] A larger quantity of material was added to allow for the presence of appreciable quantities of inert material.
* Pretreatment additive.

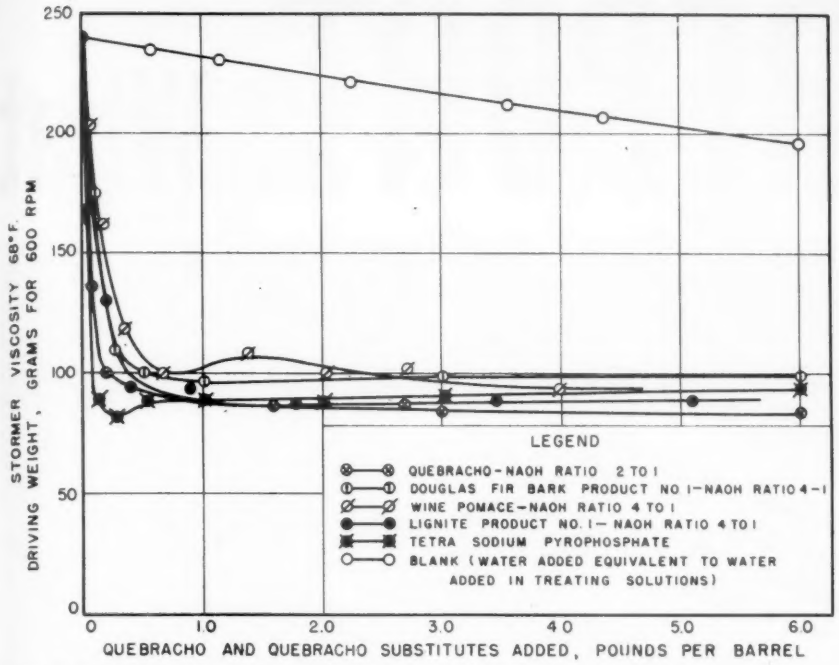

FIG. 1. EFFECT of quebracho and different substitutes on viscosity of an Alvin, Texas, shale-water drilling fluid.

TABLE 3. Effect of high temperatures on Frazier Mt. (Calif.) clay-water mud treated with Quebracho and Quebracho substitutes.

Sample number	Treating material	Standard API filter test: Quantity of material added, lb per bbl	Filtrate volume, ml. Time mud held at 200 F, hours: 0	3	6	Temp. F	Stormer viscosity, 68 F, 600 rpm driving weight, grams. Blank (H_2O added to untreated mud equivalent to H_2O in treating solutions) Time mud held at 200 F, hours: 0	3	6	Treated drilling fluid: Quantity of material added, lb per bbl	Time mud held at 200 F, hours: 0	3	6	Ratio[1] of NaOH to treating material
1a.	Quebracho	3.5	7.5	12.0	12.2	72	245	280	295	3.5	130	180	180	½
1b.	Quebracho	3.5	11.1	10.[illegible]	9.0	72	245	280	295	3.5	165	380	370	¼
2a.	Lignite product No. 1	3.5	10.0	15.8	17.8	72	245	280	295	3.5	130	215	225	½
2b.	Lignite product No. 1	3.5	10.2	11.2	12.2	72	245	280	295	3.5	140	250	280	¼
3.	Wine pomace	[2]4.5	11.0	13.6	14.6	72	245	280	295	4.5	140	180	190	¼
4.	Douglas fir bark product	[2]4.5	9.6	13.0	12.9	72	245	280	295	4.5	150	400	370	¼
5.	Tetrasodium pyrophosphate	2	11.8	11.8	11.4	72	245	280	295	2	110	203	245	None
6.	Lignite product No. 2	3.5	10.0	11.2	11.4	72	245	280	295	3.5	140	215	240	¼
7.	Hemlock bark	[2]4.5	11.6	14.2	11.4	72	245	280	295	4.5	130	240	270	¼
8.	Redwood bark product	3.5	9.4	16.0	15.4	72	245	280	295	3.5	140	270	250	¼
9.	Douglas fir bark product No. 2	3.5	11.0	14.7	14.4	72	245	280	295	3.5	140	250	260	¼
10.	Calcium ligno sulfonate	3.5	10.2	18.0	18.5	72	245	280	295	3.5	150	360	310	¼
11.	Tannery waste product	3.5	13.2	18.8	19.0	72	245	280	295	3.5	150	210	215	½
12.	Wattle bark extract	3.5	8.6	11.2	13.6	72	245	280	295	3.5	140	210	215	½
13.	Chestnut wood extract	...	....	....	....	..	...	...	...	...	...	...	...	..
14.	Pecan shell extract	...	....	....	....	..	...	...	...	...	...	...	...	..
15.	Lignite product, quebracho blend	3.5	13.2	18.7	21.8	72	245	280	295	3.5	145	190	180	½
16.	Canaigre root	...	....	....	....	..	...	...	...	...	...	...	...	..

[1] As some of the products contained either NaOH or appreciable quantities of inert material, different ratios of NaOH to treating material were necessary to keep the ratio of the NaOH to the soluble material between ½ and 1.
[2] A larger quantity of material was added to allow for the presence of appreciable quantities of inert material.

from these materials in treating most hole muds, because the pH of the muds tested were in the range generally found in most drilling operations.

Before treatment with these materials the pH values were about 9.7 and, except for the muds treated with sodium acid pyrophosphate, the pH at the end of the tests ranged from 10.6 to 11.8. The filter tests were made on the muds after the final or maximum quantity of the treating material had been added.

Results of Tests

Table 1 compares the 15 selected substitute materials with respect to their effectiveness in controlling the viscosity and filter properties of two California and one Texas drilling mud and in registering salt contamination and heat deterioration in a California mud. Considering their availability, these materials are listed roughly in the order of their effectiveness as practical substitutes for quebracho extract. Accordingly, some of the better substitutes are far down the list due to their limited supply. Douglas fir bark product No. 1 is high on the list primarily because of the large quantities available, although it is somewhat inferior in resisting salt contamination and heat deterioration.

A comparison of the more effective and available substitutes, such as wine

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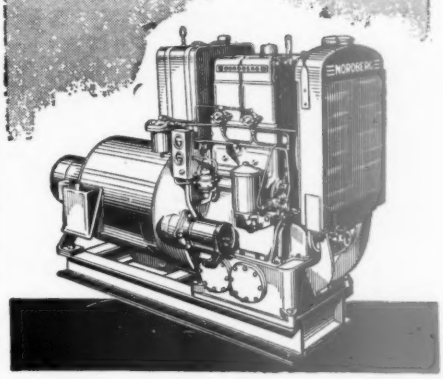

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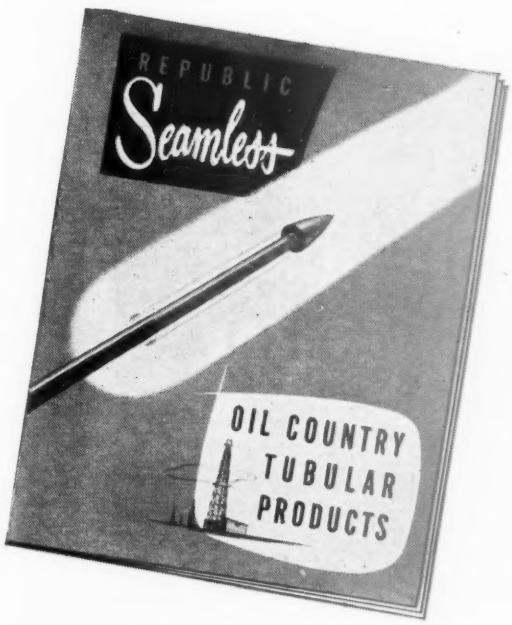

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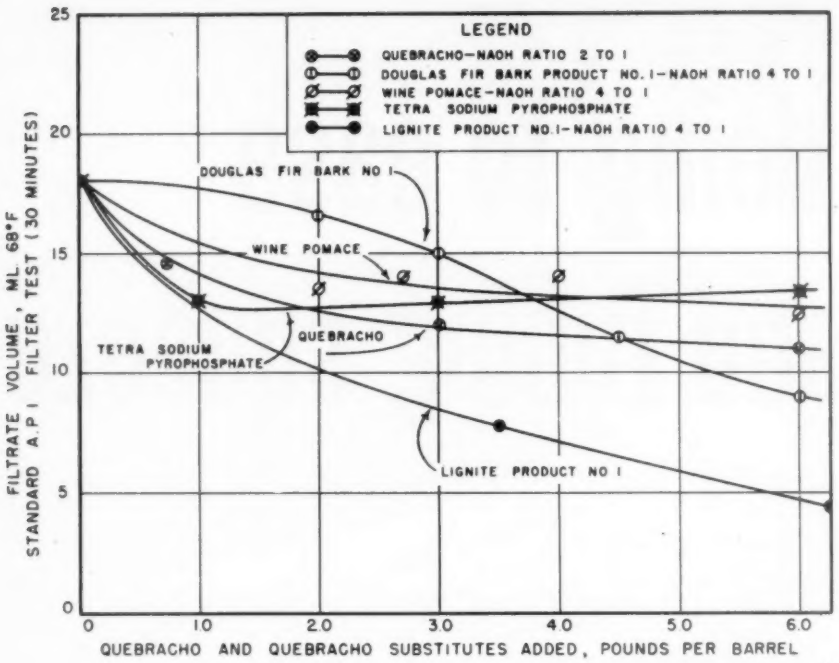
LEGEND
QUEBRACHO—NAOH RATIO 2 TO 1
DOUGLAS FIR BARK PRODUCT NO. 1—NAOH RATIO 4 TO 1
WINE POMACE—NAOH RATIO 4 TO 1
TETRA SODIUM PYROPHOSPHATE
LIGNITE PRODUCT NO. 1—NAOH RATIO 4 TO 1
DOUGLAS FIR BARK NO 1
WINE POMACE
QUEBRACHO
TETRA SODIUM PYROPHOSPHATE
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FILTRATE VOLUME, ML 68°F STANDARD A.P.I. FILTER TEST (30 MINUTES)
QUEBRACHO AND QUEBRACHO SUBSTITUTES ADDED, POUNDS PER BARREL

FIG. 2. EFFECT of quebracho and different substitutes on filter rate of an Alvin, Texas, shale-water drilling fluid.

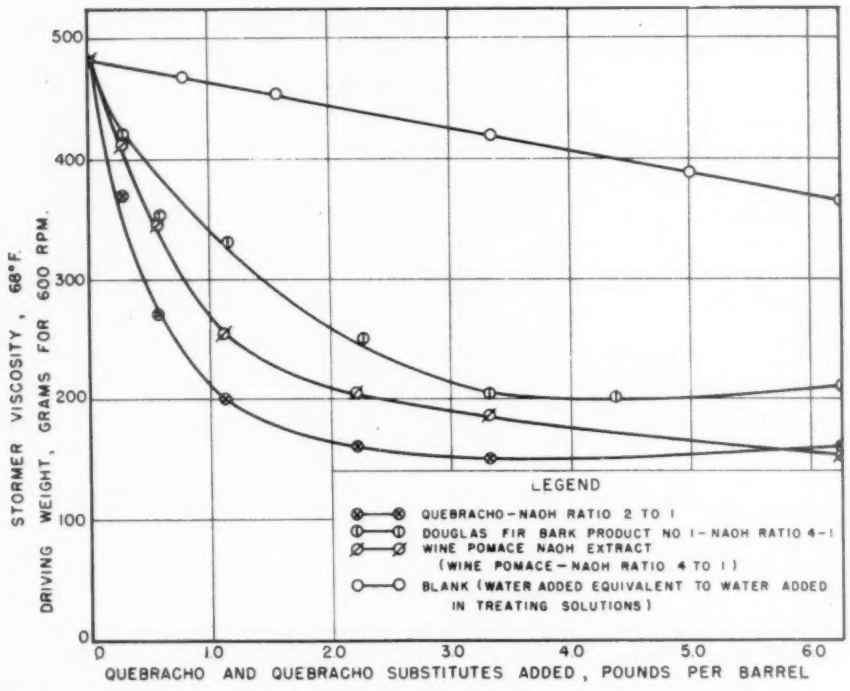
LEGEND
QUEBRACHO—NAOH RATIO 2 TO 1
DOUGLAS FIR BARK PRODUCT NO 1—NAOH RATIO 4—1
WINE POMACE NAOH EXTRACT (WINE POMACE—NAOH RATIO 4 TO 1)
BLANK (WATER ADDED EQUIVALENT TO WATER ADDED IN TREATING SOLUTIONS)
STORMER VISCOSITY, 68°F. DRIVING WEIGHT, GRAMS FOR 600 RPM.
QUEBRACHO AND QUEBRACHO SUBSTITUTES ADDED, POUNDS PER BARREL

FIG. 3. EFFECT of quebracho and different substitutes on viscosity of a cement contaminated drilling fluid from a California well.

pomace,[3] Douglas fir bark No. 1, lignite product No. 1, tetra sodium pyrophosphate, and quebracho on the viscosity of the Alvin (Texas) shale mud shows that each of these substitutes closely approaches quebracho in controlling the viscosity of that drilling fluid. (See Fig. 1.)

The comparative effect of these materials on the filter properties of Alvin (Texas) shale mud is shown in Fig. 2. The data show that in low concentrations in the drilling fluid Douglas fir bark No. 1 is inferior to quebracho, but in higher concentrations it closely approaches quebracho. Wine pomace is reasonably close to quebracho in its effectiveness in controlling the filter properties of Alvin (Texas) shale mud. On the other hand, lignite product No. 1 is superior to quebracho in controlling the filter properties of the mud.

The effect of two of the most abundant of these materials (Douglas fir bark product No. 1 and wine pomace) on the viscosity of a cement contaminated mud taken from a California well is shown in Fig. 3. These materials were found to be nearly as effective as quebracho in reducing the viscosity of that drilling fluid.

The effectiveness of 12 of the substitutes in resisting salt contamination, when added to a Frazier Mountain drilling fluid is shown in Table 2. It will be noted that the viscosities of all the pretreated mud samples were adversely affected by salt contamination. Fig. 4 graphically compares the effectiveness of wine pomace, Douglas fir bark, lignite products, and quebracho in resisting salt contamination. The data show that quebracho and lignite product No. 1 were superior to the other materials in resisting salt contamination. It was found also that the pretreated samples, in which the ratio of treating material to sodium hydroxide was 2 to 1 were more resistant to salt contamination than the samples in which the ratio was 4 to 1.

As shown in Table 3, the application of heat resulted in an increase in the viscosity of all Frazier Mountain mud samples that were pretreated with thirteen of the substitute materials. It will be noted that quebracho is superior to all of the other materials, including lignite product No. 1, in its resistance to heat deterioration. This is particularly important in drilling deep wells where the formation temperatures are high. As with salt contamination, heat deterioration of quebracho and lignite product No. 1 was found to be greater in the mud samples in which the ratio of treating material to sodium hydroxide was 4 to 1 than in those in which the ratio was 2 to 1. The effects of high temperature on the mud samples treated with the substitute materials that are probably the most practical substitutes (wine pomace, Douglas fir bark, and lignite products) tested are shown in Fig. 5.

Because clays from some California dry-lake beds have long been used extensively in drilling muds in California, a study was made of the effect of certain substitutes on the viscosities of muds prepared from two of the dry-lake clays. None of the materials tested, including quebracho, reduced the viscosities of the muds appreciably when used with sodium hydroxide. (See Fig. 6.) In fact, most of the materials caused the viscosities to increase. Consequently, these materials, including quebracho, are not recommended for use in muds containing appreciable quantities of dry-lake clays. When it is desirable to use quebracho with muds containing appreciable quantities of dry lake clays it can be used effectively in combination with one of the complex phosphates, as is illustrated in Fig. 6.

Availability of Substitutes

Results of these tests indicate that that from an over-all viewpoint lignite product No. 1 is the best of the quebracho substitutes tested by the Bureau of Mines. It closely approached quebracho both in its effectiveness and in the quantity required to obtain equal results. Large quantities of this material are available, and it is now being sold in appreciable quantities to the oil industry. According to Averitt and Berryhill,[4] the estimated recoverable

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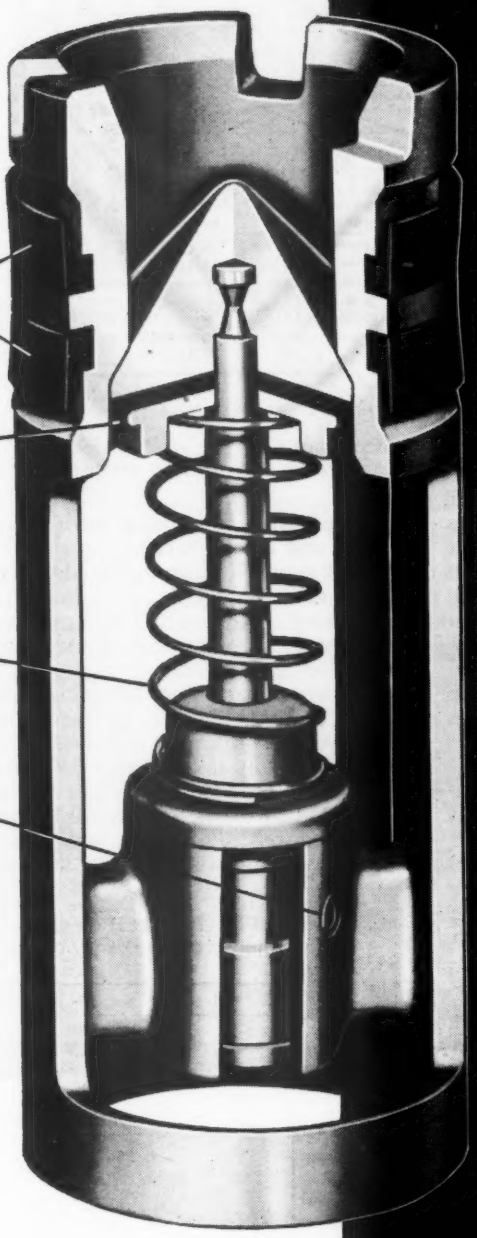

SIDE SEALS REVERSED

to prevent distortion of seals by trapped fluid. Valve is easily removed.

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The redesigned seal between the valve and the valve seat seals better—lasts longer—*stays in place* even under high circulating volumes and high pressures.

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Reduces the cutting action of circulating fluid on the valve seal and seat.

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The valve guide is securely held in place by the set screw.

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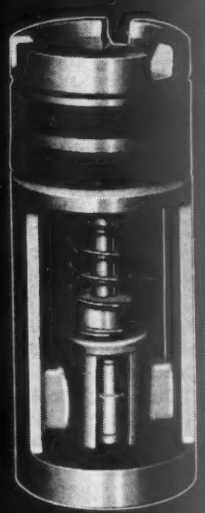

Baker Model "F" Drill Pipe Float Valve, Product No. 4813

Suggestions of drilling contractor and drilling department personnel have helped in redesigning and improving Baker Drill Pipe Floats so that they are *now better than ever.* They will save *you* time and money, muss and fuss, in every string.

POSITIONED WHERE DESIRED—A majority of operators install the Baker Drill Pipe Float Valve in a recess in the lower end of the drill collar where it is held in position by the pin on the drilling bit. Or the Valve can be positioned in a Drill Pipe Float BODY which serves as a tool joint sub at any point in the string.

EASILY INSTALLED AND SERVICED—The strong, simple Valve is made without threads and is merely dropped into place—or just as easily removed—by hand. No tools or wrenches are required. The inexpensive wearing parts are available at your supply store, and servicing is quickly and easily done right on the derrick floor.

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PICK ONE UP AT YOUR SUPPLY STORE—TODAY

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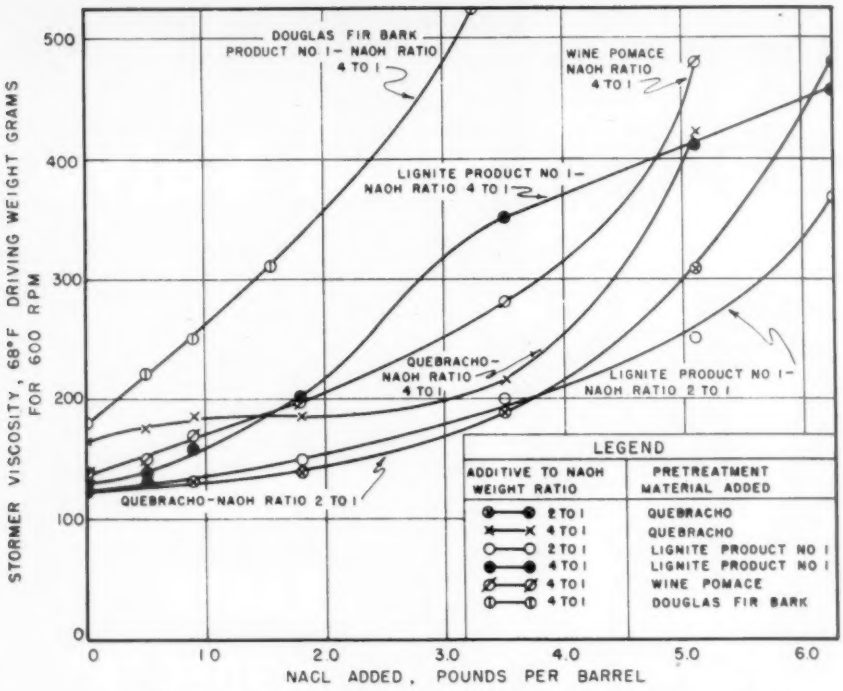

DOUGLAS FIR BARK PRODUCT NO 1 – NAOH RATIO 4 TO 1
WINE POMACE NAOH RATIO 4 TO 1
LIGNITE PRODUCT NO 1 – NAOH RATIO 4 TO 1
QUEBRACHO – NAOH RATIO 4 TO 1
LIGNITE PRODUCT NO 1 – NAOH RATIO 2 TO 1
QUEBRACHO – NAOH RATIO 2 TO 1
LEGEND
ADDITIVE TO NAOH WEIGHT RATIO
PRETREATMENT MATERIAL ADDED
2 TO 1 QUEBRACHO
4 TO 1 QUEBRACHO
2 TO 1 LIGNITE PRODUCT NO 1
4 TO 1 LIGNITE PRODUCT NO 1
4 TO 1 WINE POMACE
4 TO 1 DOUGLAS FIR BARK
STORMER VISCOSITY, 68°F DRIVING WEIGHT GRAMS FOR 600 RPM
NACL ADDED, POUNDS PER BARREL
0
100
200
300
400
500
1.0
2.0
3.0
4.0
5.0
6.0

FIG. 4. EFFECT of sodium chloride on viscosity of a Frazier Mt. (California) clay-water drilling fluid pretreated with quebracho and different substitutes.

reserves of lignite in the United States as of January 1, 1950, assuming 50 per cent recovery, total 355,725 million short tons. It should be recognized, however, that many lignites are not suitable for use in oil-well drilling muds.

The findings show that wine pomace is the second best domestic substitute of the materials tested, but in most of the drilling fluids tested larger quantities of this material were required to give the same results as those obtained with quebracho. The Wine Institute of San Francisco, California, estimates that approximately 63,000 tons (7 per cent moisture) of wine pomace are available in California wineries each year at a much lower price than quebracho. In 1952 it was sold as a stock-feed ingredient for 1 to 2 cents per pound.

The Douglas fir bark product compared very favorably with quebracho in its effectiveness in treating the drilling fluids under most conditions, although in nearly all tests larger quantities of this material were required to produce the same results obtained by treating with quebracho. Findings show, however, it is not entirely satisfactory in its resistance to salt water and high temperatures. This by-product is of particular interest because tremendous quantities are available at low cost. According to the Oregon Forest Products Laboratory of Corvallis, Oregon, about 2,500,000 tons of Douglas fir bark are available at sawmills in this country each year. In 1951 most of the Douglas Fir bark was burned in waste burners at the mills or was ground and sold as a low-cost fuel. Douglas fir bark product No. 1 is already being commercially produced and is being used in some areas.

Tetra sodium pyrophosphate was quite effective in treating the drilling fluids, and as compared to quebracho smaller quantities were required to give the desired properties. In a national emergency, however, the complex phosphates probably will be needed in several other industries.

Redwood bark and hemlock bark products were found to be reasonably effective substitutes for quebracho under most conditions. The redwood bark product was nearly equal to quebracho on a weight basis, but considerably more of the hemlock bark was necessary to give the same results as quebracho. It has been estimated that the redwood bark product could be made available in large enough quantities to supply an appreciable part of the quebracho requirement, but the quantity is relatively small compared with some of other substitutes, particularly Douglas fir bark. The supply of the hemlock bark product is uncertain.

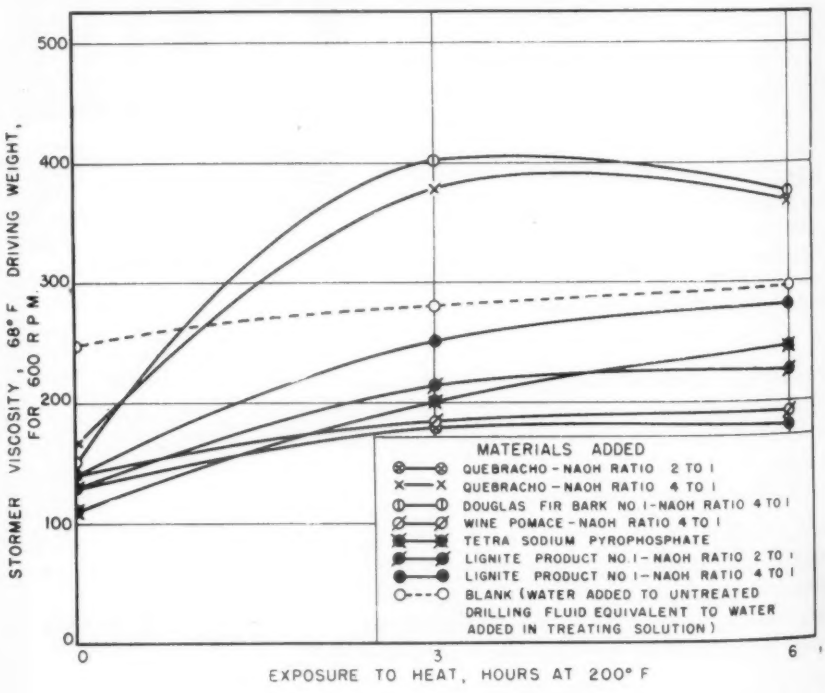
Wine pomace and Douglas fir bark product No. 1 are fibrous products, which possibly could be used effectively to prevent lost circulation.

Calcium ligno sulfonate also was found to be a reasonably good substitute for quebracho in treating the three native-clay drilling fluids, but it was so highly susceptible to salt contamination that it is not recommended for use in areas in which salt may occur. The major use for which calcium ligno sulfonate has been recommended as a quebracho substitute is in lime muds, and not in the typical native-clay drilling fluids. As the material is a lignin by-product of the paper industry, the potential supply is very large.

Wattle bark extract was found to be nearly as effective as quebracho in controlling the properties of the drilling fluids. This material is an imported product from South Africa. According to the Department of Commerce, over 85,000,000 lb were imported in 1952. Other tanning extracts imported in 1952 are as follows: Mangrove extract, 7,337,985 lb; hemlock extract, chestnut extract, more than 69,000,000 lb, and divi divi, 1,303,436 lb.

One of the materials tested, of particular interest, was a synthetic tanning material. Although this material was effective in tanning leather, it was ineffective in treating drilling fluids. Thus, effective leather-tanning mate-

FIG. 5. EFFECT of heat on viscosity of a Frazier Mt. (California) clay-water drilling fluid pretreated with quebracho and different substitutes.


MATERIALS ADDED
QUEBRACHO – NAOH RATIO 2 TO 1
QUEBRACHO – NAOH RATIO 4 TO 1
DOUGLAS FIR BARK NO 1 – NAOH RATIO 4 TO 1
WINE POMACE – NAOH RATIO 4 TO 1
TETRA SODIUM PYROPHOSPHATE
LIGNITE PRODUCT NO 1 – NAOH RATIO 2 TO 1
LIGNITE PRODUCT NO 1 – NAOH RATIO 4 TO 1
BLANK (WATER ADDED TO UNTREATED DRILLING FLUID EQUIVALENT TO WATER ADDED IN TREATING SOLUTION)
STORMER VISCOSITY, 68°F DRIVING WEIGHT, FOR 600 R.P.M.
EXPOSURE TO HEAT, HOURS AT 200° F
0
100
200
300
400
500
3
6

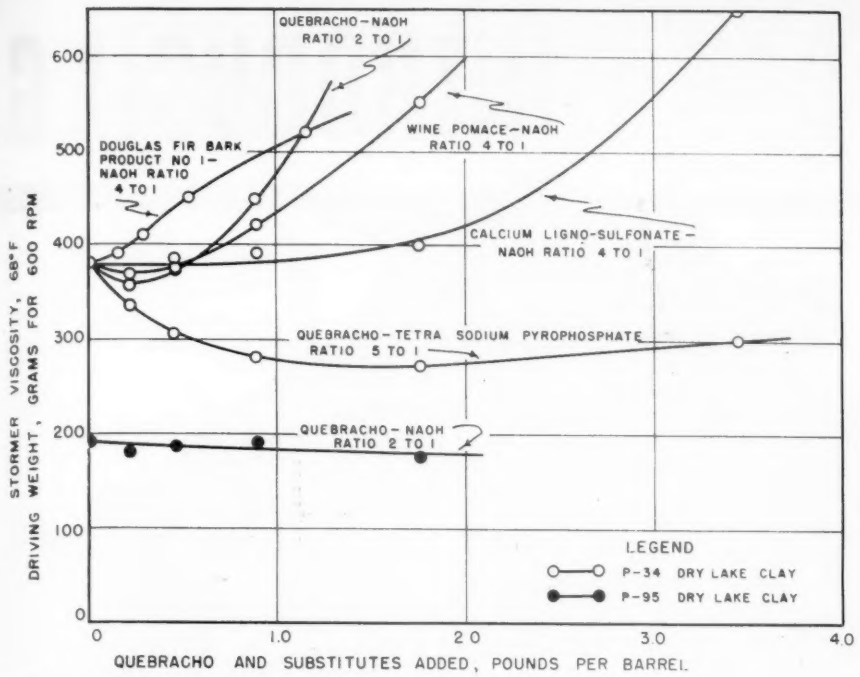


FIG. 6. EFFECT of quebracho and different substitutes on viscosities of two California dry lake clay-water drilling fluids.

rials are not always effective in treating drilling fluids.

Results of these tests indicate that:

1. Several materials of domestic origin approach quebracho in effectiveness in controlling the properties of the three drilling muds under the conditions specified.

2. Several of these domestic materials are not as expensive as quebracho.

3. All of the products except lignite product No. 1 and Wattle bark were inferior to quebracho in their resistance to sodium chloride contamination in the mud used in these tests.

4. All of the products were inferior to quebracho in their resistance to high temperatures in mud used in these tests.

5. None of the domestic materials tested were equivalent to quebracho in all of the tests, especially when compared on a pound-for-pound basis, but lignite product No. 1 and wine pomace approach quebracho in overall effectiveness.

6. Of the domestic materials tested those that are probably of the most practical interest as quebracho substitutes are, (1) lignite product No. 1, (2) wine pomace, (3) Douglas fir bark No. 1, (4) complex phosphates, (5) redwood bark product, and (6) hemlock bark.

7. These tests are not considered conclusive; more comprehensive tests using many other types of native-clay drilling fluids having a wide range of pH values should be made before the materials can be completely evaluated. Field tests of these materials also are essential for a complete evaluation. Lignite No. 1 and Douglas fir bark product No. 1 already have been used in drilling many wells.

Acknowledgements

Investigation was conducted under the supervision of R. A. Cattell, chief,

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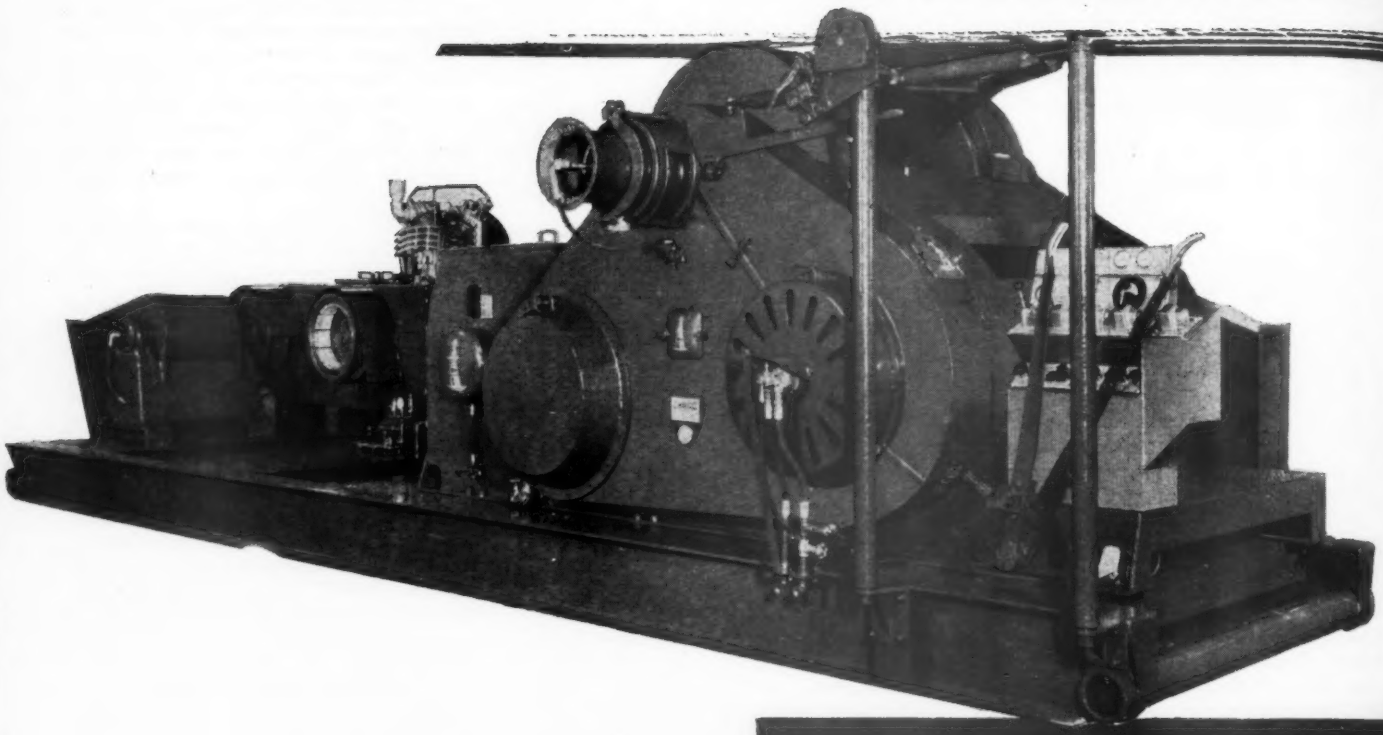

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In the GC-500, the drawworks — with built-in selective speed transmission — and compounding transmission are mounted on a common skid and can be transported as a unit. It is never necessary in tearing down or rigging up to break chains, oil lines or air lines. The result is a substantial reduction in hole-to-hole downtime.

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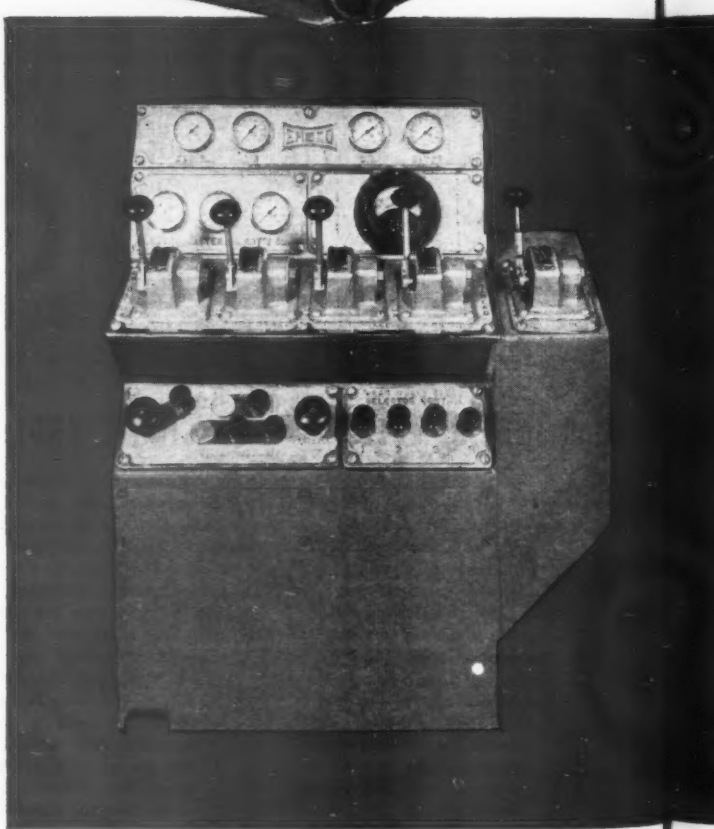

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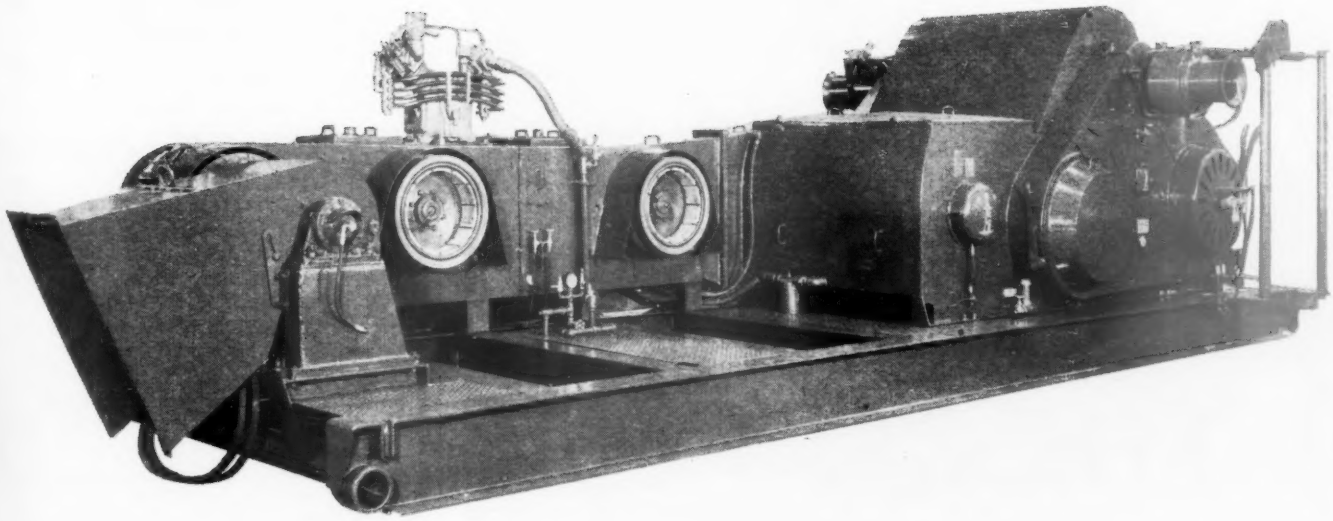
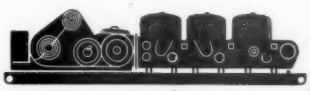


CHOICE OF ENGINES AND CHOICE OF COMPOUNDING TRANSMISSIONS

No. 52 Compounding Transmission



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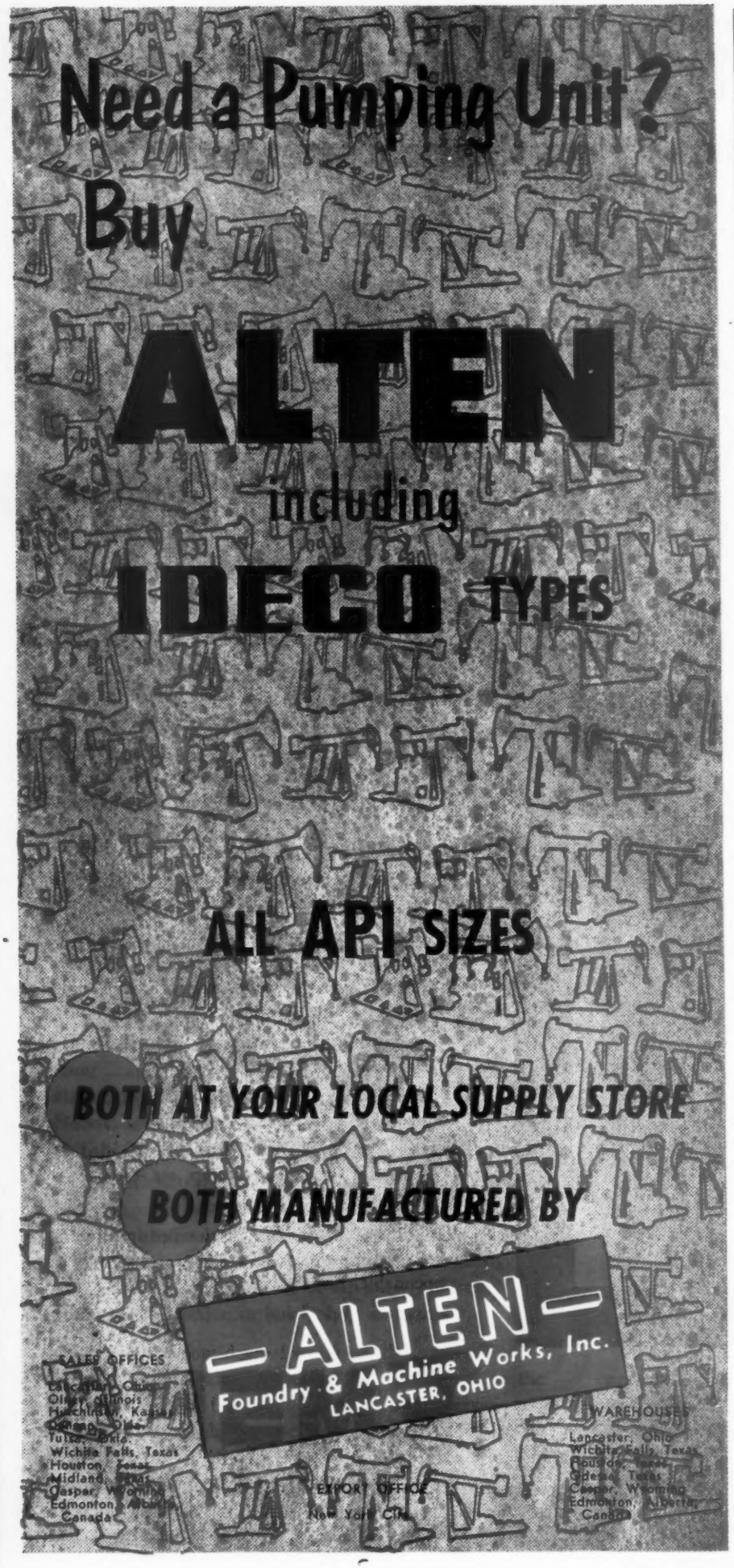

Petroleum and Natural Gas Branch, Bureau of Mines, Washington, D. C., G. B. Shea, chief, Fuels Technology Division, Region III, and under the direct supervision of G. L. Gates, Federal Bureau of Mines, San Francisco, California.

The writer is indebted to the following organizations for supplying samples and helpful information used in conducting the investigation and preparing the report: Western and Eastern Regional Laboratories of the United States Department of Agriculture; Baroid Sales Division, National Lead Company; Weyerhaeuser Timber Company; Pacific Lumber Company; Wine Institute; Oregon Forest Products Laboratory; Richfield Oil Company; American Cynanamid Company; Rohm and Haas; Sunshine Products; Van Waters and Rogers; Schelling and Smith; Marathon Corporation, West Virginia Pulp and Paper Company; Mead Corporation; Texas Tannin Extract Company; Magnet Cove Barium Corporation; Heyden Chemical Company; Natal Tanning Extract Company, Ltd.; Union Oil Company of California; Alrose Chemical Company and Hercules Powder Company.

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References

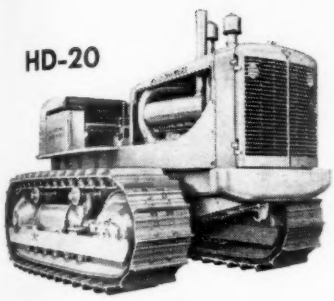
1. United States Imports of Merchandise for Consumption, Commodity by Country of Origin; Foreign Trade 110, Bureau of Census, Department of Commerce.
2. The viscosities of the muds were measured with a Stormer viscosimeter, and their filter properties were determined in a standard A.P.I. filter press in accordance with the procedures described in American Petroleum Institute Recommended Practice for Standard Field Procedure for Testing Drilling fluids, May 1950.
3. Wine pomace is the solid residue that remains after pressing the juice from the grapes; it contains seeds, stem fibers, skins, and pulp.
4. Averitt, Paul, and Berryhill, Louise R., Coal Resources of the United States: U. S. Geological Survey Circular 94, December 1950, p. 1.

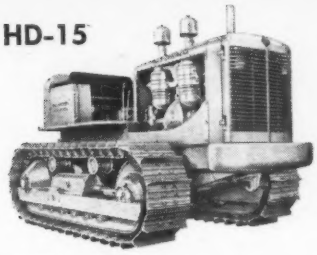
* * *

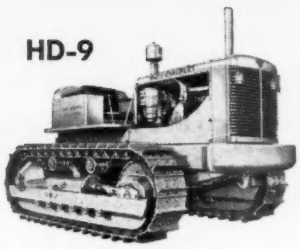
AIOC Drilling in England

Anglo-Iranian's prospecting subsidiary, has commenced drilling at Plungar, Nottinghampshire, England, about 23 miles south of Eakring where company has small producing field. The well will be taken to 3,500-ft.

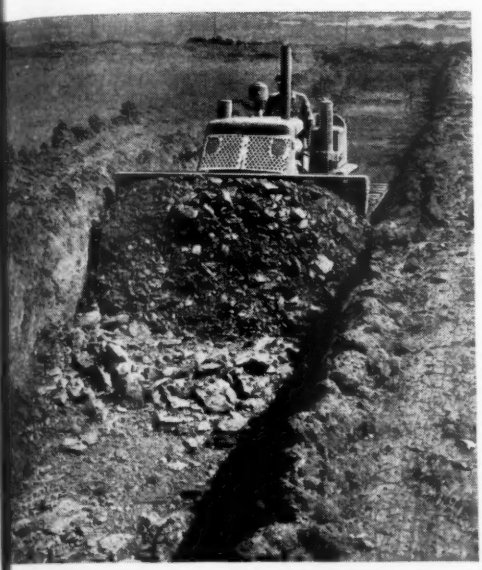
Anglo-Iranian's first test well in Sicily has been begun at Vittoria, by the D'Arcy Exploration Company. Permits have been granted to "search for and produce oil" in certain areas in Southern and Eastern Sicily. Italian contractors will carry out work with a rig capable of reaching 8,000-10,000-ft. Exploratory work is completed.







There's more to tractors than meets the eye...



This 72 drawbar hp., 18,800-lb. HD-9 is an all-round oil field workhorse and, equipped with the 9X dozer, it's an outstanding performer on slush pit digging. Operators can gain up to 25 percent more production on short dozing jobs because they can go from any forward to any reverse speed with just one shift.

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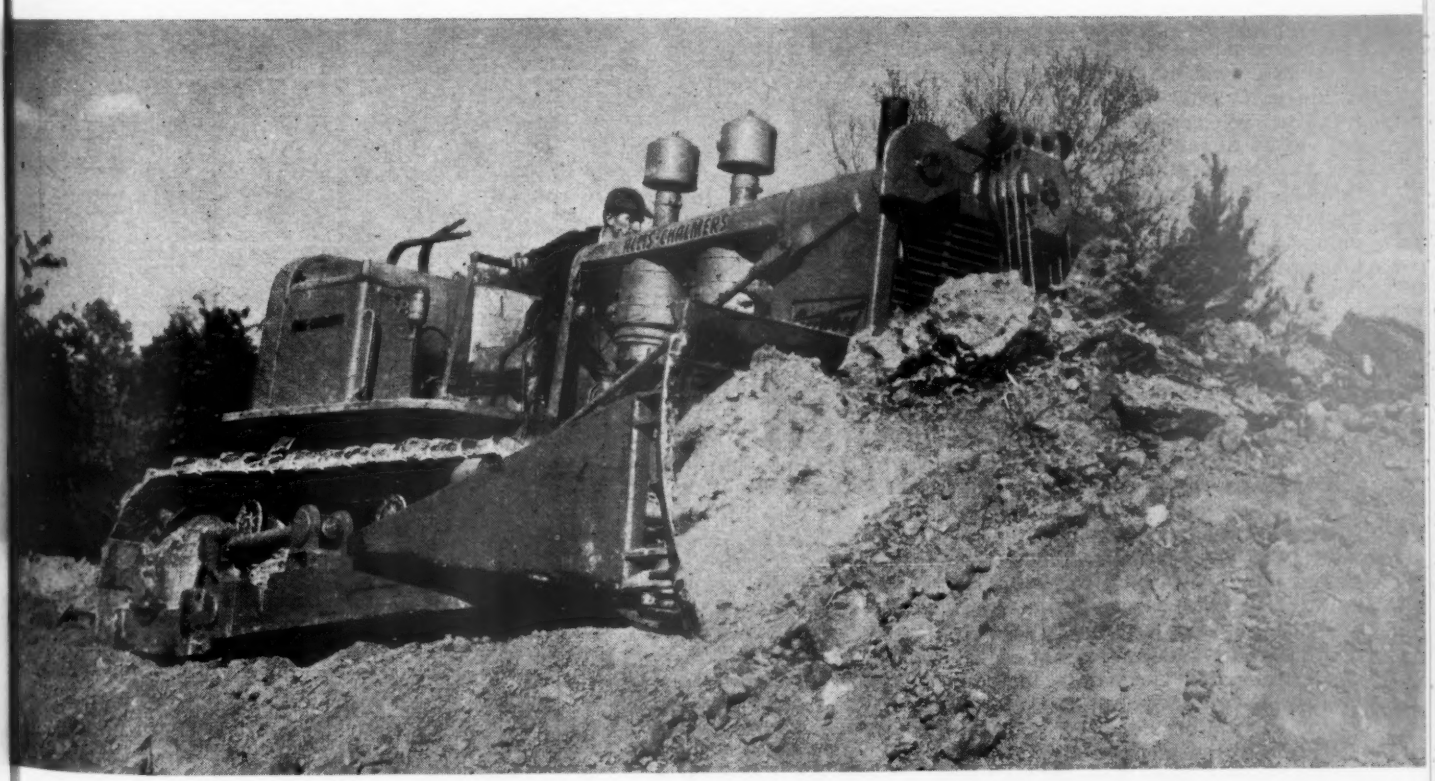

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Secondary recovery almost equals primary production at Cities Service Patterson Block in Greenwood County, Kansas, as

Waterflood Project Nears Predicted Output

FRANK BEACH, E. E. FUNK, M. M. HARDIN

THE Patterson project is a group of leases owned by Cities Service, which comprises about 90 per cent of a small Bartlesville sand pool in Greenwood County, Kansas. This small pool is sometimes called the Hamilton pool after the town of Hamilton which is situated about one mile south.

The Patterson project after the usual primary production history has proved to be one of the most successful waterflood projects in East Kansas. The waterflood recovery to date has been 6171 bbl of increased oil per acre or 186 bbl per acre foot. This recovery has been accomplished with a very favorable ratio of 7.4 bbl of input water to 1 bbl of produced oil.

The Patterson Block was drilled rather late in Greenwood County oil development history. The reason for the late development was three dry holes drilled within one mile of the eventual discovery well which held back exploratory drilling in the area until 1929 when Patterson 1-A was drilled for a producer. The development of the field proceeded rapidly and the primary development was virtually complete in 1930.

At the time the Patterson Block was developed it was not the practice to accumulate reservoir information. Therefore, the well and field histories consist mostly of sand cutting description and oil production records. A few wells flowed initially but with wide open production all wells soon had to be pumped. At this time no cores were taken, nor were bottom hole pressures obtained or gas volumes measured accurately.

In the late 1930's and early 40's Cities Service and other companies were benefiting from gas repressuring. As a test a portable gas compressor was installed on the Patterson Block to determine the pressure required to inject sufficient gas into the sand for beneficial results. The results of the test were satisfactory and gas repressuring on the Patterson Block was started into 3 wells early in 1940. Gas repressuring was carried on until waterflooding was started in 1946. At the time waterflooding was started gas repressuring had effected an increase over primary production of 135,933 bbl or 679 bbl per acre.

In 1946 the results of a few successful waterflood tests were being observed in Greenwood County. The price of crude was advancing and refineries were demanding more oil. As a result of these factors Cities Service decided to venture into the problem of waterflooding some of its Greenwood County properties.

As an aid to the decision to start a waterflood project there were available a few core analyses, engineering studies and some performance data on pilot tests in which Cities Service owned an interest. From this information several curves of estimated performance were drawn up to predict water input and oil and water production for the Patterson Block. From these curves and estimates on investment costs it was predicted that waterflooding should be quite profitable.

Results of core analysis of other waterflood projects in the area indicated that the Bartlesville sand contained from 30-45 per cent connate water. For the Patterson Block it was estimated that the sand would contain 35 per cent connate water. Sand thickness was known in the Patterson Block but because the thickness was obtained from sand cuttings it was estimated that the drillers logs of good sand should be reduced by 20 per cent to arrive at a figure for effective sand thickness. Porosity as determined from other core analysis was estimated at 17 per cent. On these bases and using a formation volume factor of 1.1 it was calculated that the Patterson Block should produce as much oil by waterflood as had been produced by primary means up to that time. The primary recovery to March 1, 1943, was 1,449,180 bbl of oil. The actual waterflood recovery to January 1, 1953, was 1,234,154 bbl and the decline curve indicates that at least 1,338,179 bbl can be recovered before the lease is abandoned. The prediction as to recovery

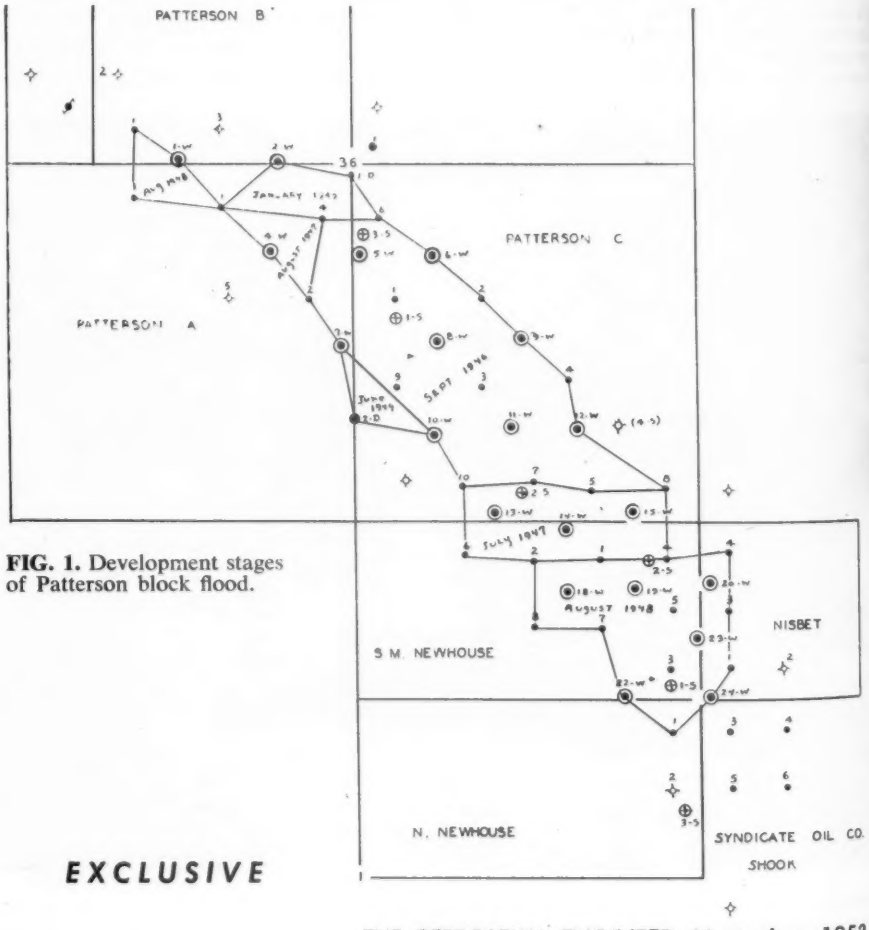

FIG. 1. Development stages of Patterson block flood.

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then was over-estimated by 111,001 bbl or 8 per cent. Considering the limited facts available for making this estimation the results were considered satisfactory.

Waterflood Development

As a pilot test on the Bartlesville sand it was proposed that eight input wells be drilled. It was assumed that an ample water supply could be obtained from the Douglas water sand but later this turned out to be a mistaken assumption. The eight input wells were drilled in 1946 and generally confirmed the prediction as to net sand and effective permeability, although porosities and permeabilities found in the eight wells were a little higher than had been expected. The eight water input wells were completed in September, 1946, and development then proceeded by stages each year until 1949 at which time development was complete. (See Fig. 1). In general the waterflood has been successful, and the problems encountered were overcome without too much difficulty. Following is statistical data on the waterflood project:

Recoveries

Total acres — primary	200
Acres affected by waterflood	137
Acre feet of sand — primary	7,586
Acre feet affected by waterflood	6,641
Primary recovery to January 1, 1953	1,569,362
Increased oil due to gas injection	135,933
Waterflood recovery to January 1, 1953	1,234,154
Total recovery to January 1, 1953	2,939,449
Primary recovery per acre (200 acres)	7,846
Gas repr. recovery per acre (200 acres)	679
Waterflood recovery per acre (200 acres)	6,171
Total recovery per acre	14,697
Primary recovery per acre foot (200 acres)	207
Gas repr. recovery per acre foot (200 acres)	18
Waterflood recovery per acre foot	186
Total recovery per acre foot	411
Estimated remaining waterflood oil per acre foot	16

Statistical

Number of oil wells	29
Number of input wells	20
Depth of Bartlesville sand	1,800 ft
Average sand thickness	38 ft
Number of water supply wells	7
Water supply formation	Douglas sand
Depth of Douglas sand	725
Average thickness	50–75 ft
Casing size — oil wells	7 in. OD
Casing size — input wells	4½ in. OD
Prime mover power supply	Gas
Prime movers	Gas engines
Daily production before waterflood	80
Peak waterflood production — daily	1,375
Accumulated water input 1-1-53	9,150,211
Accumulated produced water	4,189,301
Accumulated increased oil	1,234,154
Ratio increased oil to water input	1: 7.4
Ratio increased oil to produced water	1: 3.4

Reservoir Calculations

	Total	Total Pool %	W.F. Area	%
Acres	200		137	
Sand thickness	38		48	
Acre feet of sand	7,586		6,641	
Porosity	17%		17%	
Pore space — barrel	10,031,401	100	8,781,774	100
Connate water	3,510,990	35	3,051,209	35
Reservoir oil and gas	6,520,411	65	5,730,565	65
Shrinkage	652,041	6.5	573,056	6.5
Stock tank oil in place	5,868,370	58.5	5,157,509	58.5
Primary production to 1-1-53	1,569,362	15.6	1,374,000	15.6
Increased oil due to gas rep.	135,933	1.4	135,933	1.5
Estimated total W.F. recovery	1,338,179	13.3	1,338,179	15.2
Total recoverable oil	3,043,474	30.3	2,848,112	32.3
Residual-non recoverable oil	2,824,896	28.2	2,309,397	26.2

The Authors

F. Beach E. E. Funk M. M. Hardin

Frank Beach is assistant secondary recovery engineer for Cities Service, Bartlesville, Oklahoma. A University of Minnesota graduate. Beach joined Cities Service in 1941 as a junior engineer. In 1943 he became district engineer of the Oil Hill district, transferring that same year to Madison, Kansas, as district engineer. He was promoted to assistant district superintendent in 1949, and to his present position in 1951.

E. E. Funk is a secondary recovery engineer for Cities Service. He was graduated from Kansas State College in 1935 and the next year joined Cities Service in the production laboratory in Oil Hills, Kansas. He subsequently served as district production engineer at Oil Hill and Madison.

M. M. Hardin began his oil career in 1926 as a roustabout for the Indian Territory Illuminating Oil Company at Seminole, Oklahoma. From 1928 to 1941 he served the company in the Oklahoma City field. After the merger of the ITIOC and Cities Service, he transferred to Madison as district superintendent. Hardin interrupted his oil career to attend the University of Oklahoma from 1936 to 1940, for his BS degree.

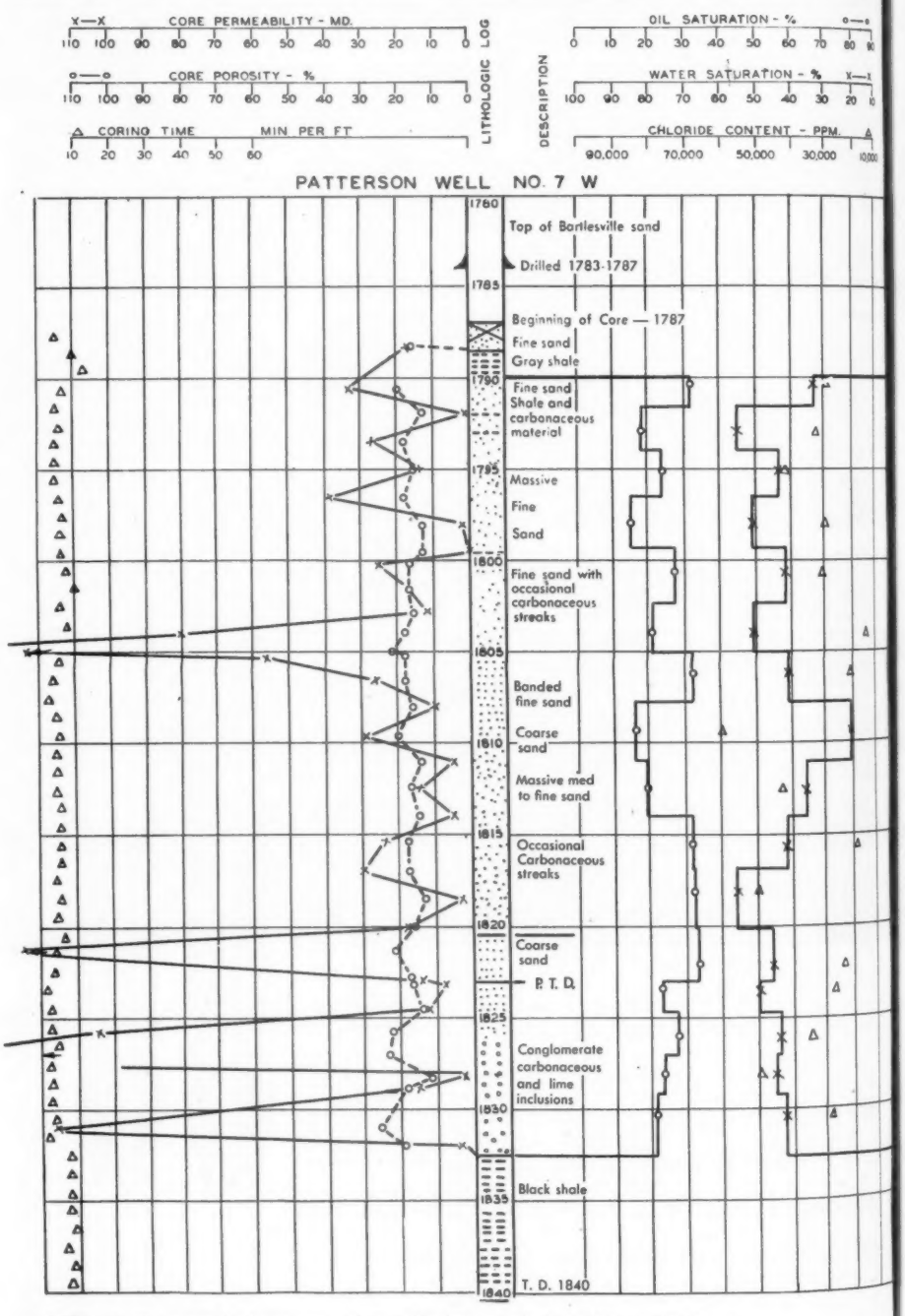


FIG. 2. Core analysis report of Bartlesville sand, injection well No. 7.

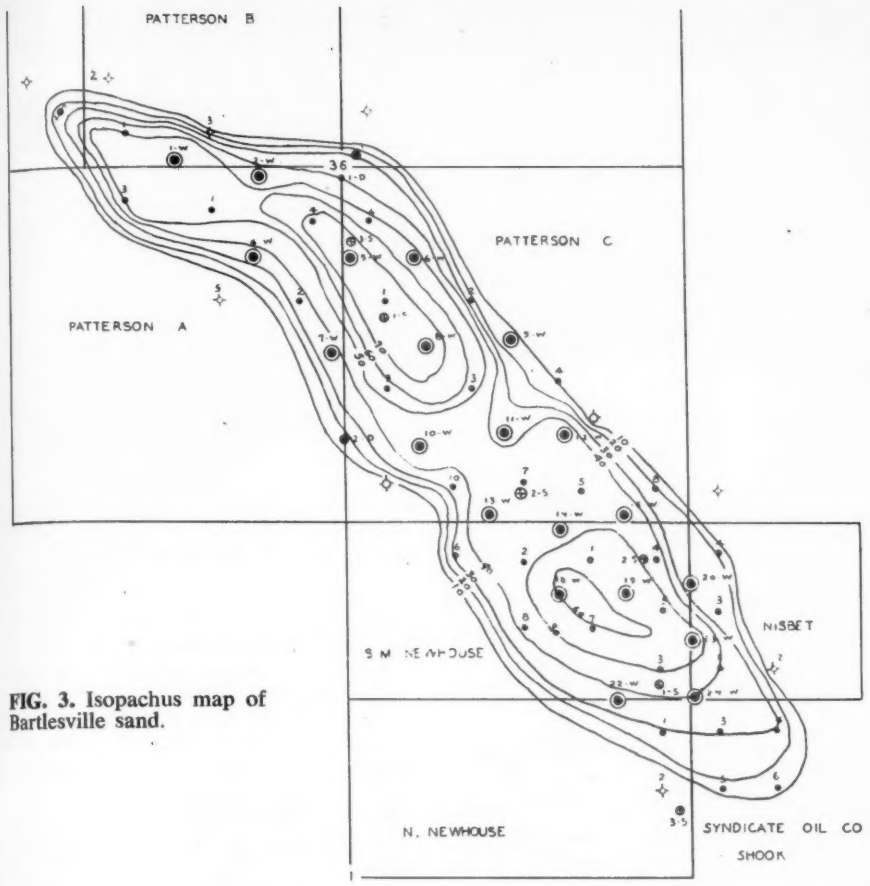


FIG. 3. Isopachus map of Bartlesville sand.

Bartlesville Producing Formation

The Bartlesville sand is of Pennsylvania age and occurs as elongated sand lenses in the Cherokee shale section. The sand in the Patterson Block occurs at a depth of 1800 ft and varies in thickness from 9 to 75 ft with an average thickness of 38 ft. The sand varies in color from gray to brown with sand of medium to fine grain with some sections containing shale and carbonaceous streaks. Permeability varies from 0 to over 200 md with a field average of 25 md. The range of permeability in the various wells is fairly high but permeability could not be correlated from well to well which probably explains why no serious bypassing of water was encountered. (Fig. 2).

Fig. 3 shows an Isopachous map on the Bartlesville sand in the Patterson pool. The sand is thicker in the middle of the section and thins out toward the edges. In some places the edges of the sand body slope off very sharply from a thick section to a thin section which made successful drilling of edge input or oil wells uncertain. Two dry holes were drilled on the edges on what was believed to be productive acreage due to the sharp slope of the sand at the edges of the pool.

Reservoir Characteristics

The Patterson pool is an elongated sand lense with impermeable shale barriers on all sides. The oil is a sweet crude with an API gravity of 39 deg to 40 deg. The primary fluid recovery mechanism was a solution gas drive. There was no evidence of a gas cap, edge water, or bottom water in the pool. From the limited information available it was estimated that the formation volume factor was about 1.1.

Water Supply

Previous to the development of the Patterson Block most of the other Greenwood County waterfloods had obtained their salt water supply from the Douglas sand and it was assumed that the same water source could be used for the Patterson flood. The Douglas sand is a sheet sand occurring over most of eastern Kansas dipping slightly from East to West. The sand in the Patterson area is found at a depth of 750 ft with a thickness of 50 to 75 ft.

It is assumed that at least 1000 bbl per day could be pumped from each Douglas supply well. S-1 was drilled with cable tools to the top of the Douglas sand, pipe set and the well drilled in and shot. When the well was produced by a pumping unit the maximum water production was 300 bbl per day. At first it was believed that this well was an exception and that a supply well in another part of the field would make a more prolific producer. In an effort to obtain sufficient water for flooding, a total of 7 water supply wells were drilled, the best of which produced about 1250 bbl per day initially and declined rapidly. The 7 wells never produced more than 2500 bbl per day. (Fig. 4). Since the waterflood development depended upon a sufficient supply of water, it was necessary to supplement the salt water supply with fresh water from a nearby stream. Therefore, during the greatest part of the life of the waterflood the input water consisted of a mixture of Douglas sand water, return water and fresh water.

Character of Water

The Douglas sand is productive of salt water with analysis as follows:

Specific gravity	1.065
P_h	6.9
Calcium Carbonate	10,019
Magnesium Carbonate	4,629
Chloride as NACL	88,986
Turbidity	40
Carbon Dioxide	16.4

This water has proved to be a very desirable water for flooding with no treatment needed if used in a closed system. However, since the supply of Douglas water proved to be insufficient on the Patterson Block, it was necessary to supplement the Douglas water with fresh water which then required filtration for a suitable input water.

Water Treatment

Water input was carried on under a closed system until it became necessary to handle the return water from the oil wells. Salt water disposal was handled in pits until the project was making about 1000 bbl of salt water per day. In November, 1947, a small filter plant was put into operation to treat and filter the mixed Douglas, return water and fresh water. Water treatment consisted of introducing alum and sodium aluminate into a 1600 bbl tank equipped with baffles. The water was then run through four—5 × 8 gravity filters to a sump where duplex pumps picked up the water for field distribution. Somewhat later a second 1600 bbl tank and aerator was added. The return water was then routed through the aerator and then mixed with the other water. When the peak of the water demand was reached, it was necessary to double the plant size by installing four more filters and another duplex pump. As production increased on the south end of the project the salt water disposal was handled by returning the produced salt water to a 1600 bbl tank where it was injected into the water input system with a duplex pressure pump. This water received no treatment. (Fig. 5).

The water treatment and handling on the Patterson Block is not entirely satisfactory as judged by today's standards. Over a period of several years the input wells have shown definite evidence of well plugging. Input pressures have steadily increased although not to a point where a satisfactory input rate would not be maintained. Some trouble was experienced with the filter sand plugging up with gummy iron deposits and occasionally filters were plugged by some oil held in suspension from the salt water return system.

The duplex pressure pumps that were used on the Patterson Block did

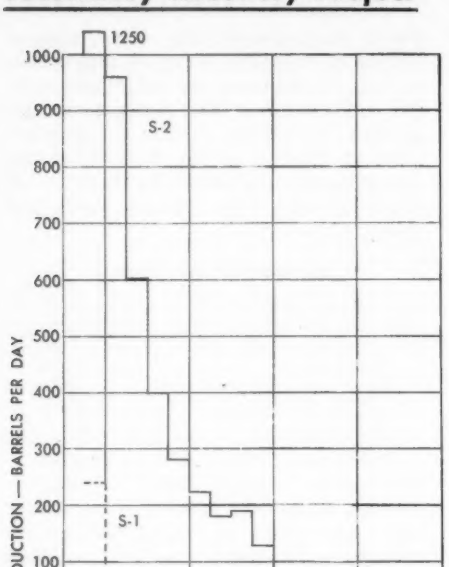
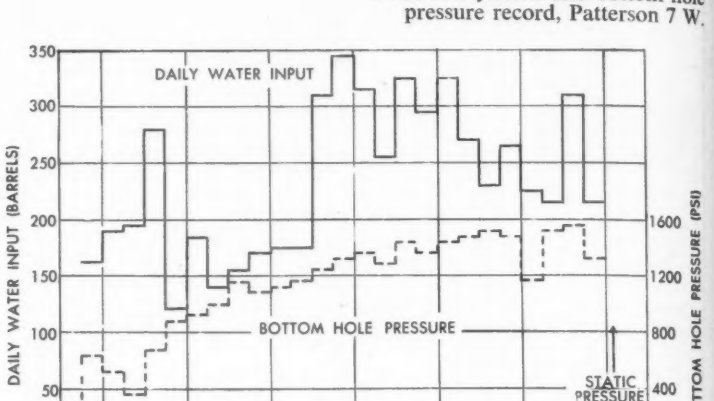


FIG. 4. Decline curves, water supply wells, Douglas sand.

FIG. 6. Injection and bottom hole pressure record, Patterson 7 W.



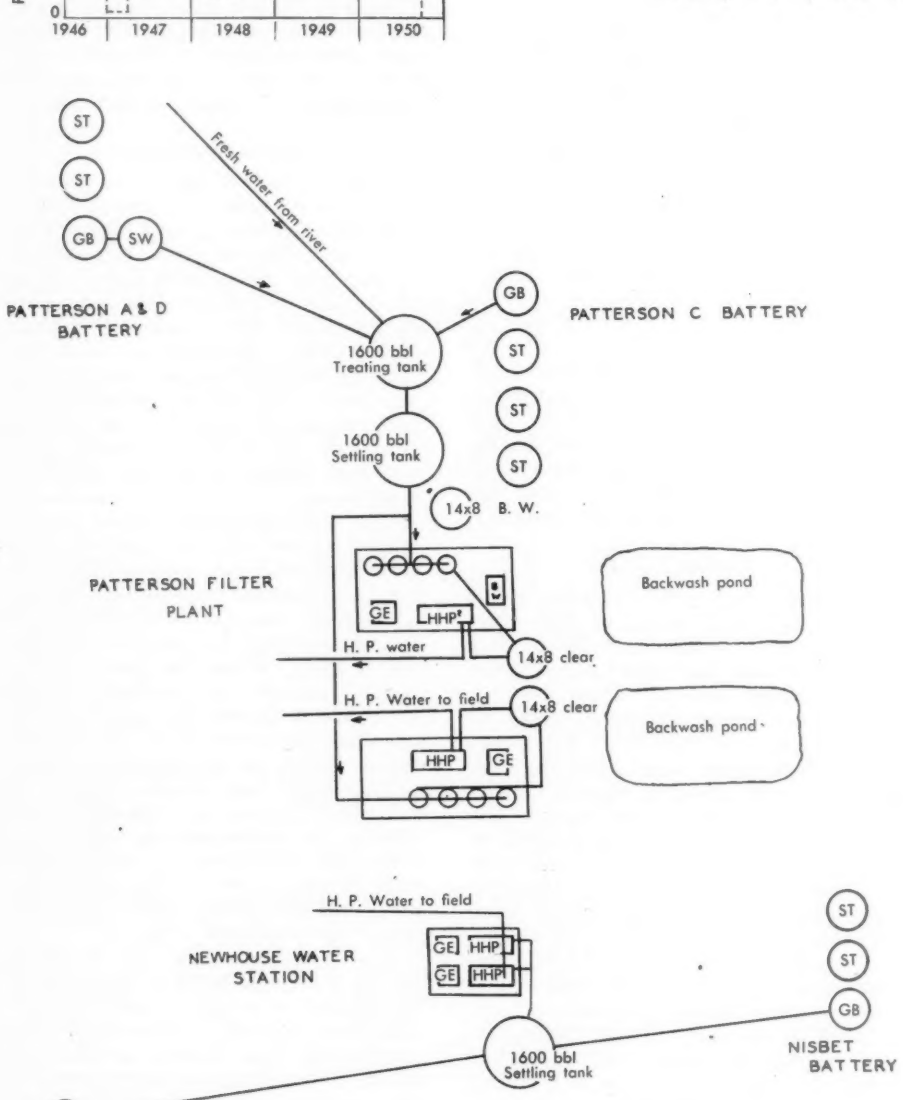


FIG. 5. Produced water handling system, Patterson block flood.

not prove to be the most desirable means of injecting water into the input system. The pumps suffered considerable down-time caused by mechanical failure. From this experience later waterfloods were equipped with the triplex type of water injection pumps.

Water Input Rates

At the start of the Patterson project water input rates were calculated on the basis of sand thickness. The maximum desired input rate was 10 bbl per day per foot of sand thickness. Later the acreage affected by each input well was taken into account and water input was calculated on the basis of acre feet of sand. The maximum desired rate of input was established at 1 bbl per day per acre foot of sand. In actual practice this desired rate of input was never attained. The average daily input over the life of the project has averaged .7 of a barrel per day per acre foot of sand.

Water input was begun in 7 wells in September, 1946. The water input data is tabulated as follows:

Year	Month	Total daily input	Number inputs	Average per well	Line input pressure lb.
1946	Sept.	1508	7	191	100
1947	Sept.	2164	12	181	300
1948	Sept.	3760	19	198	500
1949	Sept.	4716	20	236	560
1950	Sept.	5275	20	264	640-940
1951	Sept.	5470	20	273	700
1952	June	3622	18	201	720

Accumulated Input	
1946	149,756
1947	851,289
1948	2,086,229
1949	3,797,935
1950	5,659,746
1951	7,624,597
1952-June	9,814,034

Water Input Pressure

Pressure required to inject water into the sand has been highly variable. Some wells filled up quickly, and soon required surface pressure to get the desired rate of input. Others took water more easily but at the present time all input wells require pressure for input.

The input history varies from well

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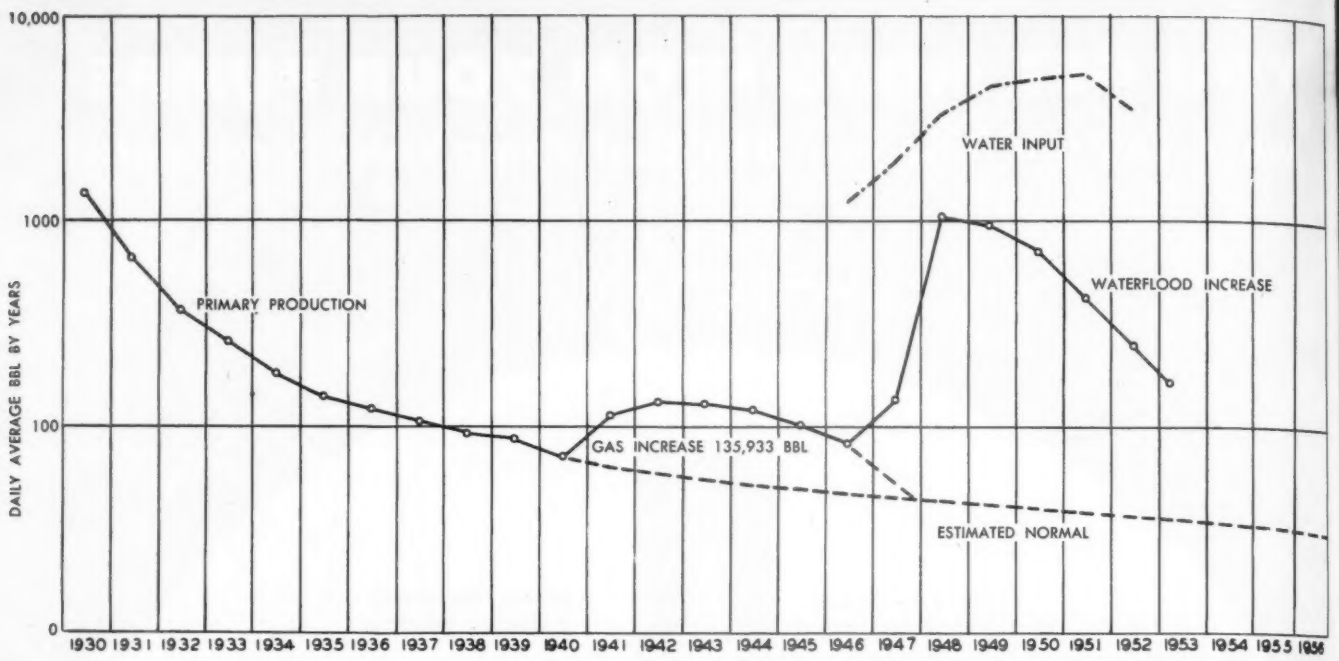

FIG. 7. Production performance of Patterson block flood.

to well but in general the input pressure rose rather rapidly for the first two years and then more or less leveled off to a small but regular increase in pressure with time. The bottom hole pressure is still increasing which indicates plugging of the sand in the input wells. (Fig. 6).

Present plant injection pressure is about 750 lb. Recent bottom hole measurements indicates that many of the input wells have several feet of cavings or sludge in the bottom of the hole.

Water Input Well Completion Practice

All of the Patterson input wells were drilled with rotary tools and the productive formation cored with the rotary core barrel. Four and one-half inch OD casing was run with float collar and guide shoe and the pipe set at the top of the sand body. Later input wells were equipped with cementing shoes which prevented access of cement to the cored portion of the hole. The wells after cementing were cleaned out and washed down with cable tools. Most of the wells on the Patterson Block were then shot with nitroglycerin or marble shots.

From experience obtained on the Patterson Block the input wells on later waterfloods were not always shot. In most of the floods succeeding the Patterson project input wells are shot only if the sand is very tight. It is probable that most of the Patterson input wells would have taken water satisfactorily without shooting.

Input Well Spacing

Due to the irregular spacing of the original oil wells, it was not possible to get a perfect 5-spot input pattern. The input wells were drilled as near to a 5-spot pattern as possible in line with the existing oil wells. Some 5-spots were covered by a greater area than 10 acres while other 5-spot patterns covered less than 10 acres. Since there are 20 input wells and 29 oil wells, it is evident that the average spacing is 10 acres per 5-spot.

Corrosion Difficulties

As a measure of protection against salt water corrosion all water input lines on the Patterson Block were cement lined. Outside of occasional collar leaks the cement lined pipe seems to have been fairly effective in salt water service. Most of the oil wells were equipped with 2-in. lead lines, which had been in service for several years prior to the waterflood. As the lead lines failed due to higher pressures and handling greater volumes of salt water the lines were replaced with cement lined lead lines. As an experiment a few plastic lines were installed for lead lines but early experience was disappointing. The plastic lines failed due to rupture in most cases. With the newer and better plastics, is is expected that plastic lead lines could be used successfully.

After about 3 years of service there were several input wells in which casing leaks occurred. Since the casing in these wells was new pipe it was suspected that stray electric currents might be causing electrolytic corrosion of the casing string. An ammeter test was run on the input lines leading to the input wells and it was found that there was an electric current through the input lines. All input lines were then equipped with insulated couplings to break the electric circuit. This remedial action seemed to reduce the incidence of casing leaks until the last year when another series of casing leaks have occurred. The latest casing leaks are believed to be due to the increasing input pressure on casing weakened by corrosion and electrolysis. Casing leaks are now being remedied by installing tubing and packers set below the zone in which the leak occurs.

Oil Production

At the time of first water input in September, 1946, the Patterson lease was making 75 bbl of oil per day from 21 producing oil wells. All oil wells were pumped by rod lines and jacks from central powers. Before any waterflood increase was noticed the lease had declined to 64 bbl per day.

In March, 1947, or 6 months after water input was started, the first waterflood increase was noticed when lease production increased to 82 bbl per day. From this date on the production increased steadily. As wells increased in production to where they could not be pumped off, the rod lines and jacks were replaced with pumping units. The pumping units were 10 hp geared units equipped with 13 hp single cylinder gas engines.

The oil wells were used as originally completed when the field was drilled. The original oil wells were drilled with cable tools to the top of the sand. Seven-inch OD casing was run and set without cementing. The sand was drilled in and shot. Outside of cleaning out a few of the oil wells no further work was necessary during the waterflood production period. None of the original oil wells were used for water input.

Production increased from 82 bbl in March to a peak of 1378 bbl in August of 1948. From that date the production gradually declined until June, 1953, when the production was down to 164 bbl per day.

The accumulated increased oil production to June, 1953, has been 1,264,340 bbl. (Fig. 7).

As might be expected from the isopachous map the greatest recoveries were obtained from the oil wells in the center part of the pool. ★ ★ ★

Oil in the Tanks

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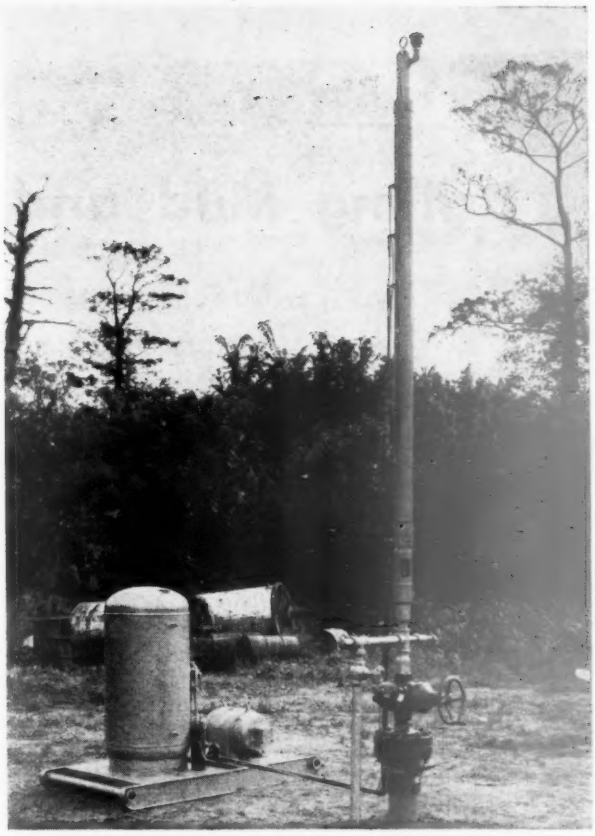

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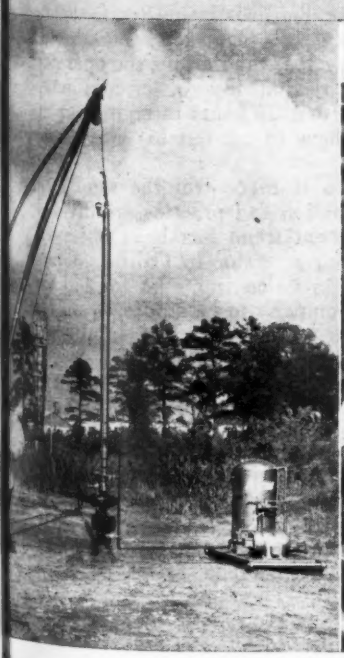

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In how many ways can an operator obtain drilling mud and mud engineering service? How does an operator accomplish his double aim of drilling a hole the most economically and getting the best possible well to the extent that proper control of the drilling mud can contribute? Where a few years ago these matters were simple concerns and there was little choice available, now there are a multitude of forms that the purchase of drilling mud materials and special drilling muds and the services of a mud engineer to control the mud can take.

It is the purpose of this discussion to summarize the current practice in California, where probably a greater variety of experiment is under way. Also, some of the factors that influence decisions on how to get the best value in drilling mud and mud engineering service will be pointed out.

Drilling mud materials are bought in many ways. Some mud materials are bought from dealers without free engineering service, some with free engineering service. These materials are ordinarily delivered as required to well locations by the dealers, but they may be picked up by the operator or contractor at the dealer's warehouse. Some materials are bought at retail or wholesale prices and put in the warehouse by the operator, or more rarely the contractor, and delivered to well locations as required. One major California operator buys all its drilling mud materials within a given area on the basis of competitive bidding. Because this company has a predictable drilling program, it can estimate and guarantee minimum requirements for six month periods in advance. Savings in unit costs by this volume buying are effected.

Drilling mud is paid for by the operator. This may seem at first to be a very obvious statement or an incompletely true one depending upon the previous experience of the reader. But whether directly or indirectly, the one who pays the bill is the operator. If he operates a company owned rig, he buys it directly. If he has a drilling contractor on a day-labor job, he buys it directly also. If he has a contractor on a footage contract, the contractor ordinarily buys it, but the operator still pays for it. The contractor may buy the mud materials and then re-sell them to the operator at the same cost or a higher one.

The Author

Harry Dodge is sales manager for Calada Materials, the Long Beach, California, drilling mud service company. A graduate of the University of California at Los Angeles, Dodge interrupted his schooling to serve in the U. S. Army from 1943-1946. After returning to UCLA to receive his AB he joined Baroid as a chemist in its Los Angeles laboratory and later moved to the field as a service engineer. Two years as district representative for the Ken Corporation followed. In 1952 he assumed his present position with Calada Materials.

The fact that a "mud-stop" is in the footage contract only changes the form in which the operator pays for the drilling mud. If a contract states that the first $1000 worth of drilling mud be provided by the contractor and that subsequent costs be passed on to the operator, obviously the first $1000 is included in the footage bid. The usual effect of a mud stop is to delegate responsibility for the drilling mud and its maintenance to the contractor. In practice he often retains this responsibility after the mud stop has been exceeded, and is spending operator funds in addition to that which he receives for the completion of his contract. The mud stop is a necessary protection in most cases against unforeseeably high mud costs. However, if a mud stop is set at a certain figure and a contractor thinks he may be able to provide his drilling mud for less, he may be tempted to run a poorer mud, (with its potential dangers), than he might if the mud stop had been set lower. Several companies are re-examining the placement of mud stops in order to avoid this possibility.

The contractor wants to drill the hole quickly, of course, and usually feels that if the primary control of the drilling mud is in his hands, he can do his job best. A low mud stop — that is, one which the operator and contractor know from judgment and experience must be exceeded to complete the hole in question, gives the contractor the protection he must have, obviates the temptation to make money on the mud stop, and conveys the responsibility which many operators and contractors wish to have the contractor assume.

That responsibility can not be assumed completely by either one or the other of the two partners, operator and contractor, in drilling a well is illustrated in situations like the following. After a stated number of hours of lost circulation of drilling mud (usually 24 hours,) the entire costs of rig and mud are borne by the operator. This is another desirable protection for the drilling contractor. No operator wants to see a contractor made bankrupt trying to complete a well for him. However, it is more than frustrating for an operator to watch a contractor maintain a mud in such a way that he, the operator, feels is risking loss of circulation — knowing that 24 hours after it happens he will have to get out his check-book again.

So who is to control the mud, and how? Opinion and practice are divided, but a recent trend has been observed. One major operator in California now specifies in its contracts let for bid the service company to be employed on the particular well involved to supply the mud materials and engineering service. This establishes a degree of responsibility between the mud engineering personnel and the operator which does not exist in many cases where the contractor alone chooses the means to maintain the drilling mud.

As to the "how" of controlling drilling mud, there are many ways in which mud engineering service is obtained and

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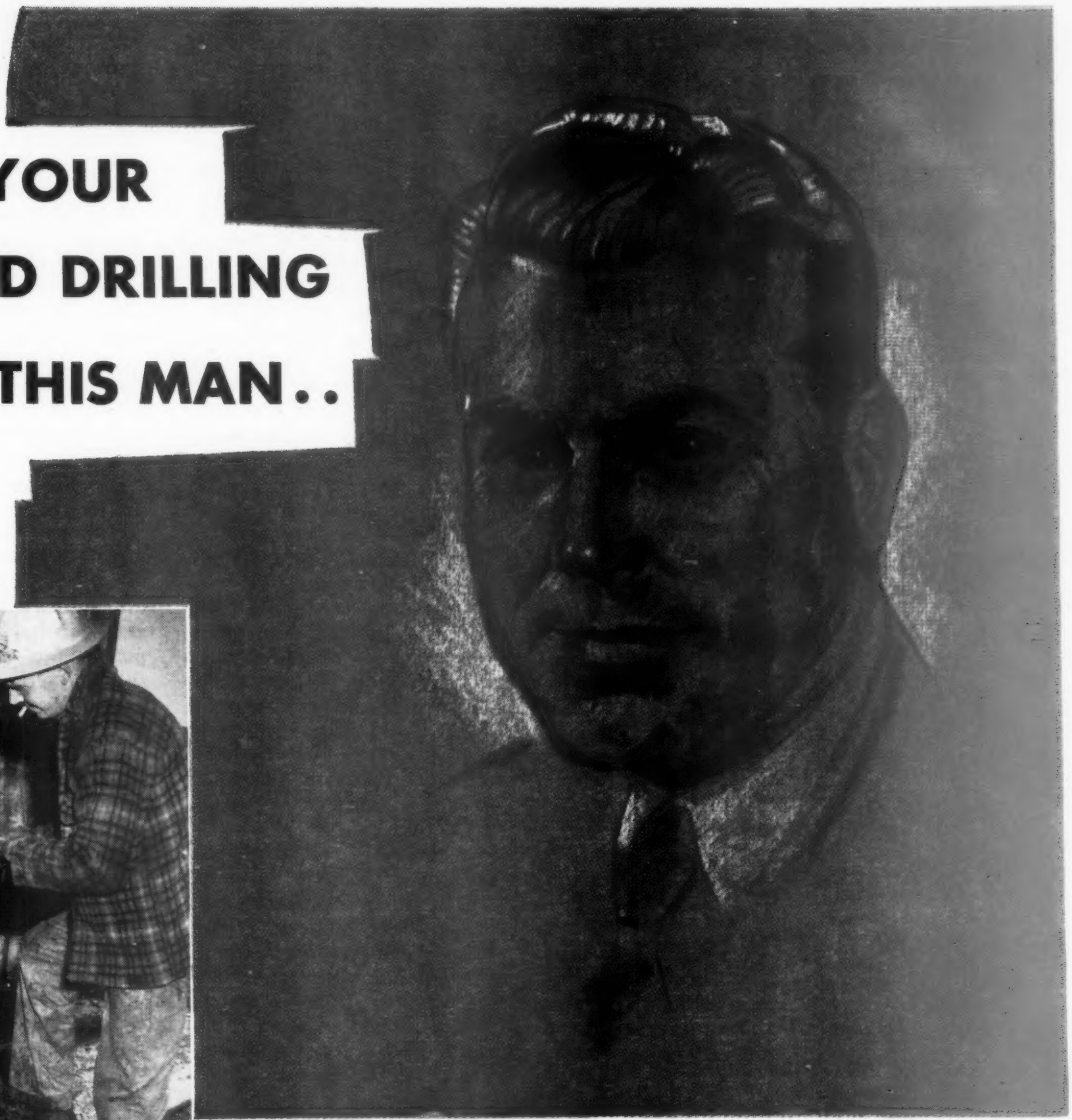

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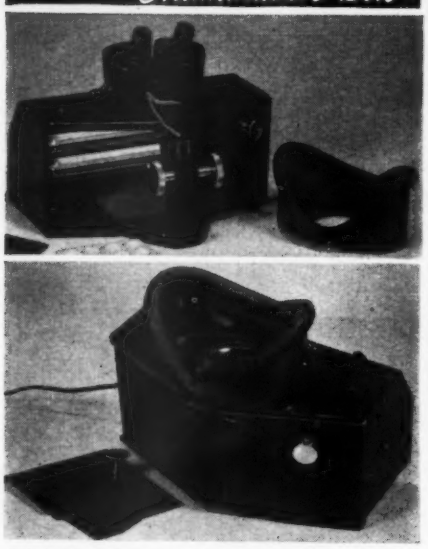

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paid for. Every well drilled with mud has a mud engineer and his service is payed for directly or indirectly by the operator. Perhaps this illustration may make this point clear: Every house built has an architect — maybe the builder or homeowner hired one or maybe he didn't. But someone, at some point, decided how wide to make the dining room, decided whether or not to include a fireplace — in other words made the decisions in the planning of the house. In the same way, with every drilling mud — someone, perhaps a derrick man who put in a sack of bentonite (or did not put in a sack of bentonite), a driller, a toolpusher, a superintendent, a service company mud engineer, a consulting mud engineer, an engineer working for the contractor, an engineer working for the operator — *someone* performed the function of a mud engineer. Usually more than one of these people are involved in the decisions made.

Probably the greatest number of drilling mud jobs in California are provided with free engineering service by the mud company supplying the mud materials. This service may vary from no service at all at one extreme, through three or four calls a week, to daily mud tests, and to the other extreme in which a service company engineer or engineers will "sit on" a well continuously during a difficult period in the course of drilling a well.

In many cases, when an operator desires personal service or more time than a service company can regularly devote, or the services of a mud engineer or engineers he feels particularly competent, he hires an individual mud engineering consultant or a company offering such service. Their fees may range from $125 to $500 per rig, per month.

Some operators have engineers whose special training and sole duties are in the control of drilling muds. Several contractors likewise have their own mud engineers.

Firms selling oil base drilling fluids without exception provide engineering service without additional charge.

In every case, mud engineering is bought by the operator, whether it is included in the contract bid, whether he pays it to his own employees, whether it is included in the price of materials, or whether it is explicitly invoiced.

Considerations as retail and less than retail mud prices, and "free" engineering service and "paid" engineering service bring to attention the subject of the expense of drilling an oil well. Every operator wants to drill his well as cheaply as possible. But is there such a thing as a "cheap" mud job?

At some place an operator might be able to buy a sack of quebracho fifty cents cheaper than somewhere else, which is an obvious saving. But what if the person performing the functions of mud engineer on this particular job puts in two sacks where one would have been adequate? Or suppose this same fellow decides *not* to put in some material or not to follow a procedure better calculated to keep the hole in good condition — and the drill pipe sticks, adding several days rig cost to the job?

Much opinion is expressed currently to the effect that neither the cost per sack of mud material or the total cost of mud materials used on a given job can tell more than a part of the story. The savings to be made here are worthwhile but they are overshadowed by the savings to be made in greater drilling rates, in avoiding hole trouble, and in preventing damage to the oil producing zone. This last factor has been too often neglected, but more and more operators now are convinced that it is pointless to spend tens of thousands of dollars to dig a hole down to an oil sand and then reduce its ability to produce oil by drilling through it with an improper fluid, merely to save a few per cent of the drilling bill.

The most skillful and reliable mud engineering service is the key to the best overall job. The mud engineer — whoever he is, whomever he is working for, and however he is paid — is a most important factor in producing the best results in terms of economy, safety and production. It must be considered that he functions within a framework of operator and/or contractor policy and supervision which are actually a part themselves of the "mud engineering". But the best *value* will undoubtedly be found in the broadest application of the wisest judgment, to which the mud engineer has much to contribute.

Certainly, as more wells are drilled in California better ways in which to provide drilling muds and mud engineering service are being developed. The responsibilities for mud control are being assumed and divided in many forms. Out of this welter of methods and experiments and trials can come a lasting progress which will benefit everyone.

* * *

Oil Men Increase Output

Oil men have learned that they can "grow" oil through the proper care and feeding of oil fields, according to OUR SUN, a Sun Oil Company magazine.

By using sound oil reservoir engineering methods — including the injection of water or gas into the earth where needed — they have recovered at least five billion barrels of oil that otherwise would never have been produced, an article in the magazine's Autumn issue states.

Figures drawn from reports of the Interstate Oil Compact Commission show that the continuation of present oil conservation practices should bring an estimated additional five billion barrels of oil to the surface.

Application of such oil-saving techniques has been made possible by discoveries resulting from an extensive research program conducted by the nation's competing oil companies.

Through these discoveries, oil producers have increased the yield from a field as much as four times. Where once only 20 per cent of the oil in a given reservoir could be produced, up to 80 per cent, in some instances, is recovered today.

Determining Most Profitable Method of Exploiting

Gas-Condensate Reservoirs

Both physical factors of the field and market value of products must be considered in selecting operating method

GEORGE HETHERINGTON and JAMES M. McDOWELL

In determining the procedure to yield the greatest profit in the exploitation of a gas-condensate reservoir, principal physical factors to be considered are size of the reservoir, richness of the reservoir fluid, absolute capacity of wells determined by formation thickness and effective permeability, and permeability variation.

Most significant economic variable is probably the relative market value of gas, including gas liquids, and condensate. If produced gas can be immediately marketed at a sufficiently high price relative to condensate, it will be unprofitable to forego this current income, and consume a part of the gas as compressor fuel, to recover additional condensate however great the increased recovery. Conversely, if gas has no market value, the revenue from additional condensate recoverable by pressure maintenance needs only to be sufficient so that, after deducting any increased operating expense and tax liability incurred, the present value of the additional condensate will more than offset the cost of installations necessary in injecting the gas. There are many other economic factors which must, of course, be considered; their effect within probable limits of variation is less significant.

If produced gas is not to be returned to the reservoir, then revenues from natural gasoline and light hydrocarbon liquids need only be adequate to cover the cost of extraction and the rather small loss of gas sales due to shrinkage to make the installation of a gasoline plant profitable. In evaluating the economics of processing gas that is being returned to the reservoir, the effect of the intermediate fractions on the effectiveness of the gas in recovering condensate must also be considered. Most of the natural gasoline, butanes, and propane left in injected gas can, of course, be recovered later when the gas sweeps through to the producing wells or after the pressure maintenance program is finished and the reservoir is being blown down.

Present investigation was originally undertaken to evaluate relative merits of conventional high pressure cycling and of cycling at lower pressure. The authors entertained some hope that a generally applicable conclusion might be reached. It proved to be feasible, however, to investigate the problem only for specific assumed values of the many significant independent variables and the conclusions are, therefore, proposed as valid only for those or very similar conditions.

A sand or granular limestone reservoir underlying 3000 surface acres at an approximate depth of 8260 ft is assumed. Average thickness of the producing formation was taken as 70 ft. The reservoir is assumed to have an expotential permeability variation of 10 with a maximum effective permeability of 36 md.

The expotential permeability variation was defined by Muskat[1] by the expression

$$K(Z) = a\, e^{bZ/H} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Formation strata were assumed to be rearranged to give a monotonic continuous permeability distribution with Z, the distance measured along the well bore. H is the thickness of the formation. The constant a is the minimum permeability ($Z = O$) and $a\, e^b$ ($Z = H$) is the maximum permeability. By definition the "variation" is the ratio of the maximum and minimum permeability. The displacement porosity is assumed constant.

Like other proposed expressions for dealing quantitatively[2,3] with variations in permeability, continuous layers of uniform permeability, without cross flow between them, are assumed. There is little relation between this highly idealized concept and any actual reservoir. It makes possible quantitative expressions, however, to describe the behavior of reservoirs into which gas is being injected. Measure of its usefulness will be the degree to which these resemble performance of actual reservoirs.

For the present problem, it is assumed that well locations and distribution of production and injection would lead to a 75 per cent areal sweep at the time when dry gas first appears at the producing wells, if the reservoir were homogeneous. For this areal sweep efficiency and the 10 expotential variation, Muskat's calculations indicate that a volume of dry gas sufficient to fill 40 per cent of the reservoir volume at reservoir temperature and pressure will have been injected at the time dry gas appears at the producing wells. This would fall within the range of actual observed behavior of reservoirs under cycling.

In actual operations, relation between the quantity of dry gas in the well stream and gas volumes injected, after first

The Authors

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George Hetherington is staff reservoir engineer of the production department, Gulf Oil Corporation, in Pittsburgh. He has been with Gulf since 1945, beginning as reservoir engineer with Western Gulf Oil Company in California. He received his bachelor's degree from the University of Colorado and did graduate work at the University of Oklahoma.

James M. McDowell is a member of the physics division of the Gulf Research and Development Company. He received his Bachelor of Science degree from Carnegie Institute of Technology in Electrical Engineering. After three and one-half years in the Army Air Force, he joined Gulf Research and Development in 1945. As a research physicist his duties include the development of analog type computers, and their use in the determination of reservoir behavior.

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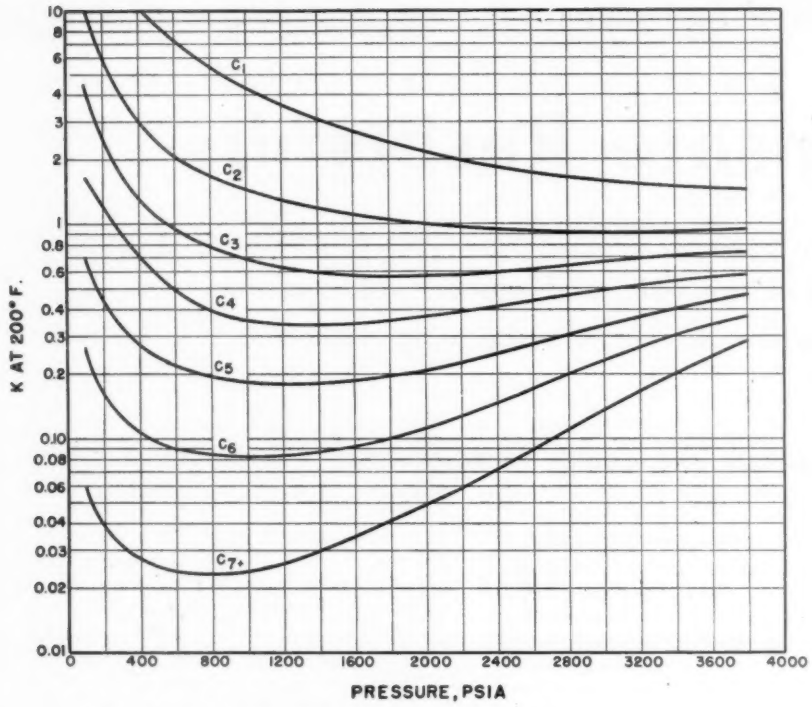

FIG. 1. EQUILIBRIUM constants used in flash vaporization calculations.

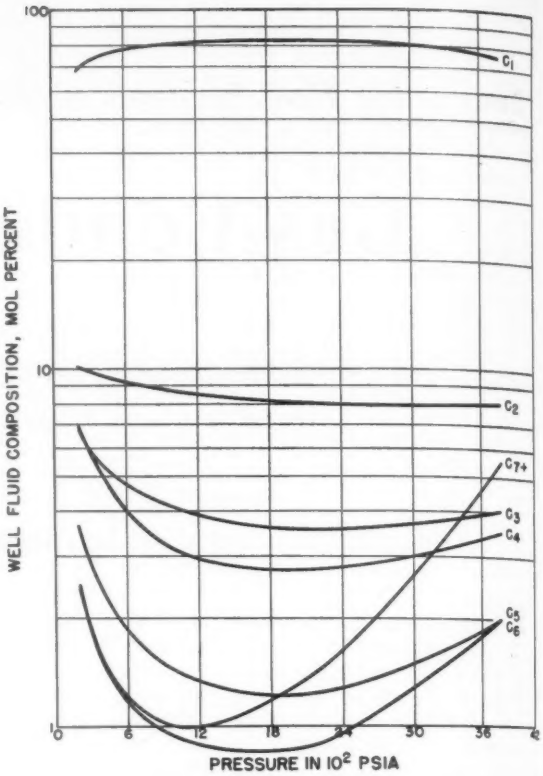

FIG. 2. COMPOSITION of produced fluid as a function of pressure during pressure depletion.

break-through, is complicated by adjustment in well rates or well repairs that are often undertaken, and obscured by the fact that the proportion of injected gas being produced is not or cannot be accurately determined. The predicted behaviors developed in the present problems by applying Muskat's calculated curve relating reservoir volumes of gas injected to the wet gas content of the well stream, and reservoir volume swept (Fig. 9) are at least not patently improbable. See Table 1.

TABLE 1. Description of the reservoir.

Average depth	8260 ft
Productive area	3000 acres
Average thickness	70 ft
Bulk volume of sand	210,000 acre ft
Average porosity	25%
Average water saturation	30%
Net void volume	36,750 acre ft
	1600.83 mil cu ft
	285,099,150 barrels
Average dry air permeability	19.5 md
Average initial effective permeability	14.0 md
Maximum effective permeability	36.0 md
Minimum effective permeability	3.6 md
Exponential permeability variation	10
Formation volume factor (reservoir (bbl/bbl debutanized condensate)	8.912
In place gas-condensate ratio (cu ft wet gas/bbl debutanized condensate)	11,310 cu ft/bbl
Original pressure	3800 psia
Reservoir temperature	200 F
Debutanized condensate originally in place	31,990,480 bbl

The weighted average effective permeability must be 14.0 md. The reservoir has a connate water saturation of 30 per cent. The average effective permeability at this saturation is taken to be 71.8 per cent of the average absolute dry air permeability. It is assumed that the curve of Fig. 12 describes the relation between effective permeability and hydrocarbon liquid saturation for all parts of the reservoir, irrespective of the absolute permeability and the connate water saturation. The effect of this assumption is to assume that, while the effective permeability is reduced by a decline in pressure and the consequent accumulation of condensed hydrocarbon liquid, the permeability variation remains the same.

The capacity of each well, drilled on 80 acre spacing, against a tubing pressure of 2000 psi was calculated to be 5,000,000 cu ft per day when the reservoir pressure is at its original value of 3800 psi. At lower pressures the capacity is less both because of the decreased available drawdown and the decline in effective permeability resulting from the accumulation of condensate in the sand. In each case the viscosity of the reservoir fluid at the applicable pressure and reservoir temperature was estimated from its composition and the data of Bicher and Katz,[4] and introduced into the estimation of well capacity. Well capacity is a critical factor in determining the most profitable method of exploiting a gas-condensate reservoir. It is conceivable that there might be reservoirs so thick and permeable that the cost of wells would be very small in relation to the value of products recoverable and the cost of compressors and a gasoline plant. In such cases, it would be almost immaterial that one plan would call for twice as many wells as another. More often the drilling and equipping of wells is a large, and often the largest, items in the cost of producing the field, and the greater productive capacity per unit of cost is an important advantage of maintaining high reservoir pressure. Cycling at the dewpoint will always lead to greater condensate recovery per well in the first years after the field is developed than either low-pressure cycling or pressure depletion.

Pressure Depletion in a Uniform Stratum

An original reservoir fluid with the following composition is assumed:

Component	Mol fraction
Methane	0.7500
Ethane	0.0800
Propane	0.0400
Butanes	0.0350
Pentanes	0.0200
Hexanes	0.0200
Heptanes and heavier	0.0550
	1.0000

The molecular weight of the C_7+ was assumed to be 130. This fluid is exactly at its dewpoint at the original pressure of 3800 psi and the reservoir temperature of 200 F. It is quite similar to the analysis of an actual condensate.

The gas deviation factor for the initial gas phase and all other gas mixtures was obtained by the use of the method and curves given by Standing and Katz.[5] Liquid volumes were determined by the method also reported by Standing and Katz.[6]

During the pressure depletion process it was assumed that only the gas phase was mobile and that equilibrium existed

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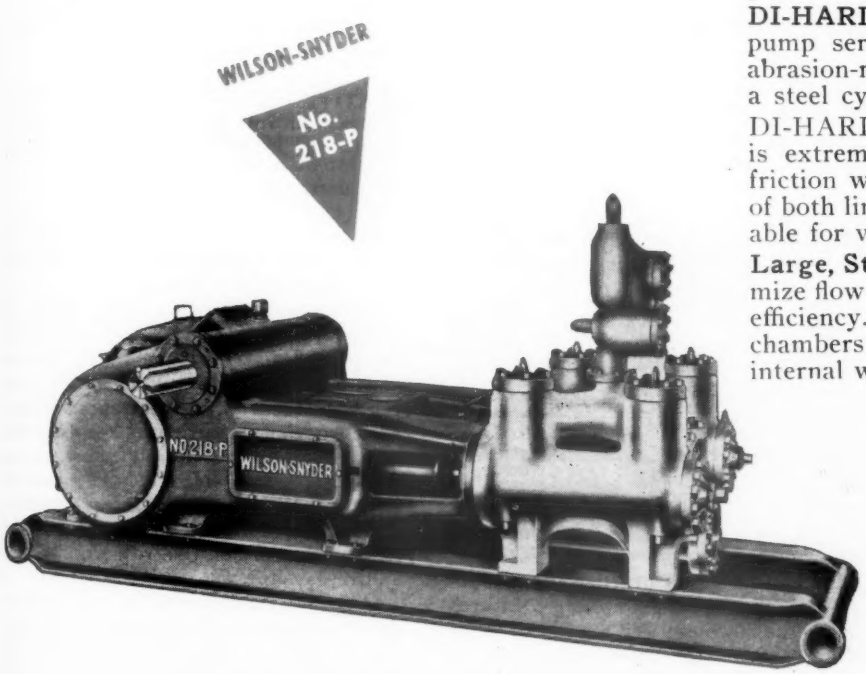

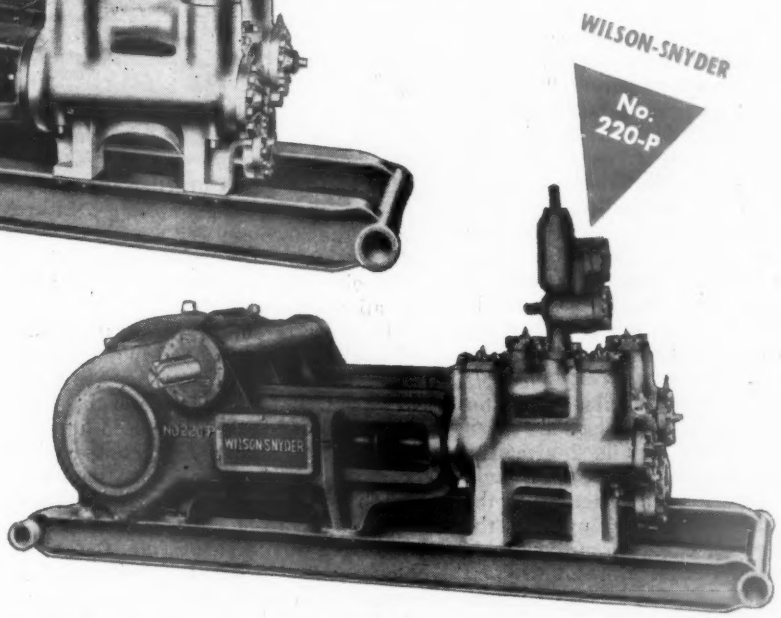

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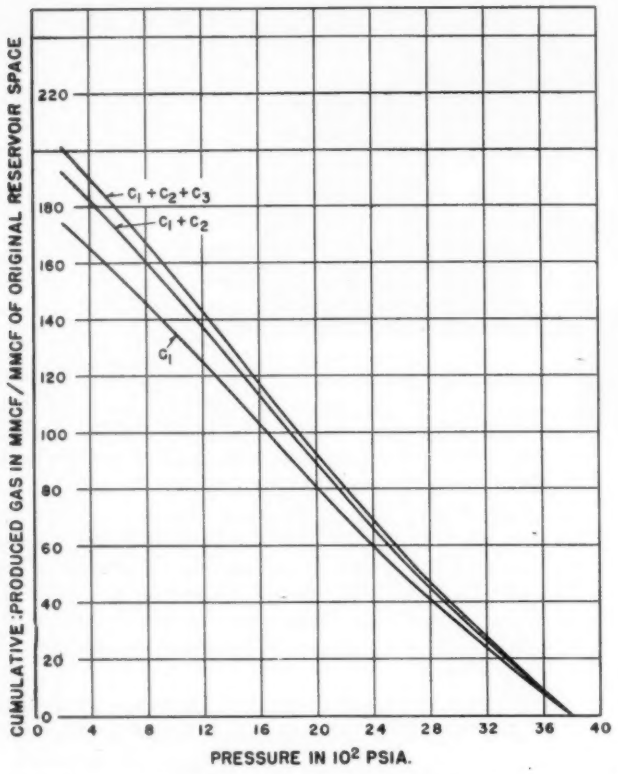

FIG. 3. CUMULATIVE recovery by pressure depletion per unit of reservoir volume of methane, ethane, and propane.

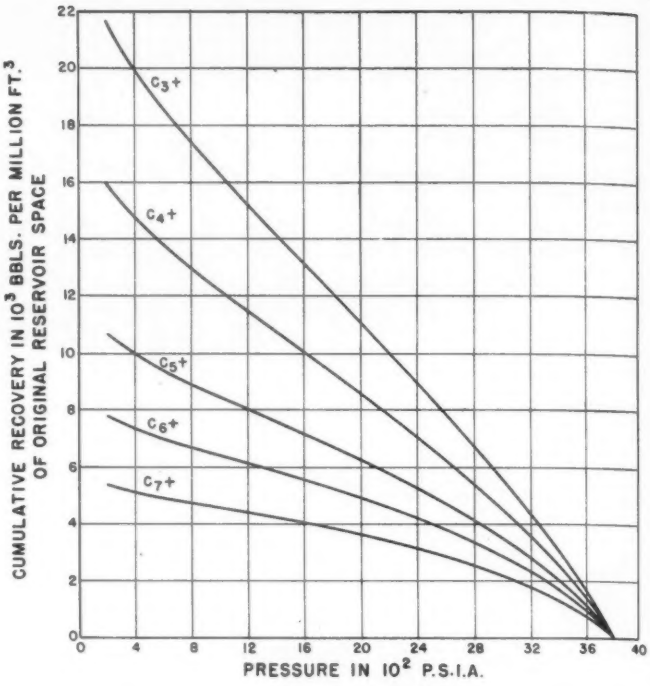

FIG. 4. CUMULATIVE recovery by pressure depletion per unit of reservoir volume of propane, butanes, pentanes, hexanes, and heptanes and heavier liquids.

at all times. This equilibrium condition was calculated for each 100 psi reduction in pressure down to a pressure of 200 psia. At each pressure level the composition and quantity of gas produced and the composition and volume of the gas and liquid remaining in the reservoir were determined. A trial and error calculation was necessary to give the exact quantity of produced gas to lower the pressure exactly 100 psi because of the changing Z factor and the density of the condensed liquid. The equilibrium constants used for the equilibrium flash calculations are given in Fig. 1. These follow closely those given by Roland, Smith and Kaveler,[7] but the convergence point has been shifted to a higher pressure in order to give a saturated gas at 3800 psia, and in addition the C_7+ curve was shifted upward to correspond to a lower average molecular weight.

The results of these calculations for the pressure depletion process are given in Figs. 2 through 6. Fig. 2 gives the current composition of the well fluid in mol fractions as a function of the reservoir pressure. Fig. 3 presents the volume of produced gas in million cubic feet per million cubic feet of original reservoir space. Fig. 4 gives the cumulative recovery expressed in barrels per million cubic feet of original reservoir space assuming that all of the propane and heavier hydrocarbons are in the liquid phase. The recovery expressed in volume per cent of initial reservoir content is given in Fig. 5. Fig. 6 shows the volume of condensed liquid in the reservoir as a function of pressure.

Quantities of Dry Gas Required for Cycling at Various Pressures

It was estimated that the gas treating plant would remove a total of 30 per cent of the propane and 90 per cent of the butanes. This would result in a dry gas of the following composition:

Component	Mol fraction
Methane	0.8701
Ethane	0.0928
Propane	0.0325
Butanes	0.0046
	1.0000

Although in actual practice the composition of the dry gas at cycling pressures below the dewpoint would perhaps differ slightly from the composition at the dewpoint, it was assumed to be the same at all pressures.

In order to simplify the calculations of cycling below the dewpoint, it was assumed that no mixing of the wet and dry gas would take place and that equilibrium between the condensed liquid in the reservoir and the injected dry gas would result in a very short time. As a rough approximation to the conditions that might exist during cycling, the reservoir was divided into ten equal blocks between the input and producing wells. An equilibrum calculation was made for each block each time the block nearest the producing well had a complete change in the gas phase content. This process was carried out until all of the liquid was vaporized and the wet gas produced with only dry gas remaining in the reservoir. The curves of Fig. 7 indicate the results of such a calculation for a cycling pressure of 3400 psia, with the quantity of produced hydrocarbons plotted against the cumulative volume of injected dry gas.

An inspection of the curves in Fig. 7 shows that the recovery of the C_5+ components is nearly a linear function of injected dry gas volume. Therefore, for the other cycling pressures it was assumed that this relation would still hold true, and it was only necessary to calculate a few steps of the previous lengthy calculations in order to determine the quantity of dry gas required to vaporize all of the reservoir liquid and replace the wet gas.

One important factor on which there does not seem to be adequate information is the time required for equilibrium to be established under cycling conditions. If one is going to assume that injected gas will soon become saturated as it shoves the wet gas ahead and comes in contact with the liquid distributed throughout the pores of the reservoir rock, it also is likely that the band between the saturated gas phase and dry gas will be small when compared with the distance between wells. If this is so, we can neglect the production of any gas of intermediate composition within a zone of uniform permeability, and assume that a wet gas saturated at the reservoir pressure is produced until sufficient gas has been injected in that permeability layer to vaporize all of the liquid and replace all of the wet gas.

The results of calculations as described above are outlined in Table 2 for each cycling pressure used. The important results are the quantities of dry gas to pick up the liquid and replace all

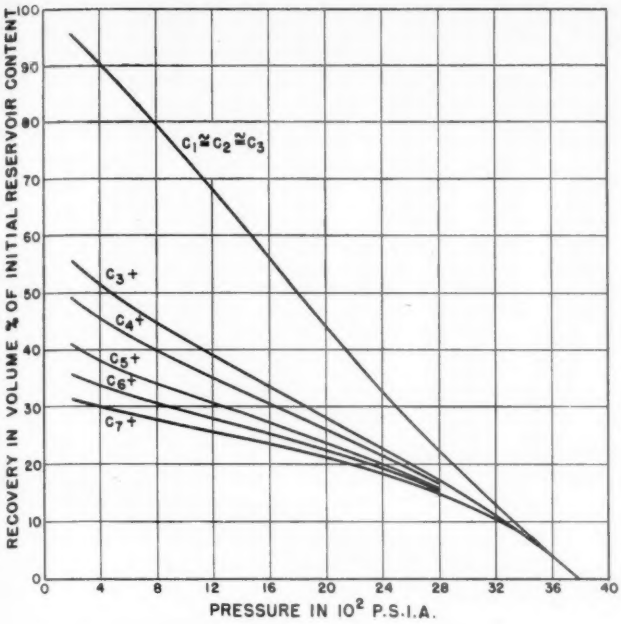

FIG. 5. CUMULATIVE recovery by pressure depletion per unit of reservoir volume as a percentage of original content.

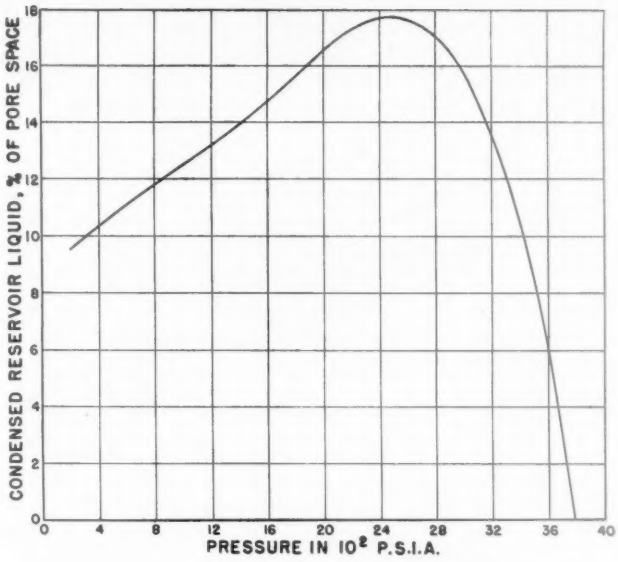

FIG. 6. CONDENSED liquid in the reservoir as a function of pressure during pressure depletion.

wet gas at each pressure and the ratio of these quantities to the amount of dry gas necessary to fill the reservoir pore space at the same pressure. This ratio is of course 1 at the dewpoint pressure of 3800 psia and increases to 1.35 at 3400 psia, 2.84 at 2500 psia, 5.49 at 1500 psia, and 10.0 at 500 psia. Fig. 8 shows how the various dry gas volumes vary with pressure. In it are plotted the volumes of dry gas measured under standard conditions to removed the initial wet gas from 10^6 ft^3 of reservoir, the dry gas required to occupy 10^6 ft^3 of pore space, and the dry gas to replace the wet gas and vaporize the reservoir liquid in 10^6 ft^3 of pore space, all as functions of the reservoir pressure.

Commercial Products From Well Fluid

In all parts of the economic analyses it is necessary to divide this original well fluid, the well fluid at various pressures less than the original, and mixtures of these indigenous reservoir gases with injected gas into commercial products to which prices can be assigned.

If the production was directly to field tanks operating at constant pressure, the character of the condensate produced would vary considerably as the reservoir pressure declined, but a cycling plant can be and usually is operated to produce a stabilized product of more nearly constant character. For the present analyses the condensate was assumed to include all of the heptanes and heavier liquids in any well stream and to have the following composition.

Component	Liquid fraction
Pentanes	0.0250
Hexanes	0.1250
Heptanes and heavier	0.8500
	1.0000

As the character as well as the quantity of the heptanes and heavier fraction of the reservoir fluid changes as the pressure declines, the gravity of this condensate would vary. But it is a common, if not universal, practice to disregard this change, and settle for stabilized condensate from a given field at a constant price. In cycling at a constant pressure, the character of the heavier fraction would remain unchanged until break-through of injected gas began. Thereafter, it would become lighter at first and finally heavier at the last. No variation in price because of gravity changes in the condensate is considered in this study. For condensate as thus defined, the gas/condensate ratio of the original well fluid is 11,309 cu ft of wet gas per barrel of debutanized condensate.

For pressure depletion and for cycling an absorber system capable of recovering from the well fluids all of the pentanes and heavier liquids, 90 per cent of the butanes and 30 per cent of the propanes was assumed, and a design and estimate of the cost of construction prepared. It was considered that all of the pentanes and heavier would go into natural gasoline, which is 4 per cent by liquid volume butane and 96 per cent pentanes and hexanes. (The ratio of the pentanes to the hexanes in all the well streams is very nearly constant and pentanes are always between 65 and 75 per cent of the gasoline.) This gasoline will have a nearly constant vapor pressure and variations in price resulting from changes in quality are not considered. All that part of the 90 per cent of butane recoverable from the well stream not going to natural gasoline is considered marketable as commercial butane and 30 per cent of the propane in the well stream is considered commercial propane. The calculations of the foregoing quantities for the original well fluid are given in Table 3.

Dewpoint Cycling

Three possible methods of exploiting were investigated in detail: (1) cycling at the dewpoint until handling of the well fluid became unprofitable followed by "blow-down" to abandonment; (2) pressure depletion from 3800 psi to 3400 psi, cycling at 3400 psi, and finally "blow-down" to abandonment; and (3) pressure depletion from the beginning.

TABLE 2. Calculation of injected dry gas volume to vaporize all liquid and produce all wet gas in 10^6 ft^3 of reservoir pore space at various cycling pressures.

Cycling pressure, psia	3800	3400	2500	1500	500
1. Z of dry gas	0.9060	0.8903	0.8768	0.9008	0.9601
2. Moles of dry gas in 10^6 ft^3	593.4×10^3	540.2×10^3	403.4×10^3	235.6×10^3	73.67×10^3
3. Standard M sCF dry gas in 10^6 ft^3 pore space	225.2	205.0	153.1	89.40	27.96
4. Liq vol after pressure depletion, per cent	0	10.53	17.72	14.25	10.73
5. Standard MMCF dry gas to replace wet gas in 10^6 ft^3 pore space	225.2	183.5	126.0	76.66	24.96
6. Moles of C_{5+} vaporized with first injection of dry gas (one-tenth of reservoir gas vol)	0	37.41×10^2	14.26×10^2	6.66×10^2	3.14×10^2
7. Moles of C_{5+} in liquid after pressure depletion (10^6 ft^3 of reservoir pore space)	0	185.8×10^2	345.6×10^2	362.0×10^2	338.3×10^2
No. of inj. (one-tenth of reservoir gas vol) to vaporize all liquid in reservoir	0	5.0	24.2	54.3	107.6
9. Average number of moles dry gas/inj	59.3×10^3	49.1×10^3	33.6×10^3	20.8×10^3	6.21×10^3
10. Moles of dry gas to pick up liquid in 10^6 ft^3	0	245.5×10^3	813.1×10^3	1090.3×10^3	668.2×10^3
11. Standard MMCF dry gas to pick up liquid in 10^6 ft^3	0	93.2	308.7	414.0	254.0
12. Standard MMCF dry gas to pick up liquid and replace all wet gas in 10^6 ft^3 of pore space	225.2	276.6	434.7	490.7	279.0
13. Ratio of line 12 to line 3	1	1.35	2.84	5.49	10.0

XUM

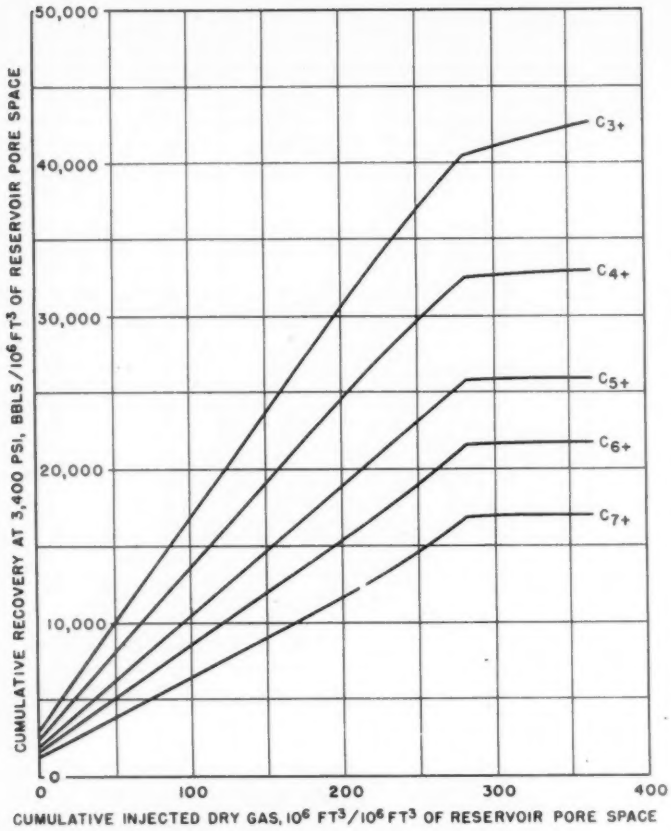

FIG. 7. CUMULATIVE recovery per unit of uniform reservoir volume by cycling at 3400 psi.

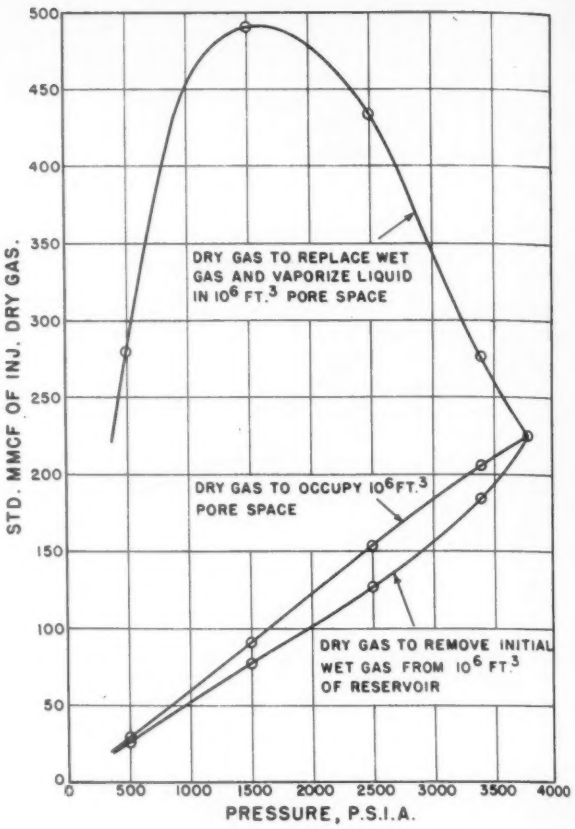

FIG. 8. VOLUMES of dry gas required to remove initial wet gas and revaporize condensed liquid in unit of uniform reservoir volume as a function of pressure.

Cycling at 500 psi was investigated but without estimating recovery by years. The economics of cycling in the pressure range between 3400 psi and 1000 psi was not investigated in detail. The calculations summarized in Table 2 and on Fig. 19, show that for cycling at 2500 psi and 1500 psi, 1.94 and 2.18 times as much gas has to be processed and reinjected to obtain the same increase in condensate recovery as for cycling at the dewpoint. The cost of process and compressor plant for handling the gas at the lower pressures would be less, but, for the reservoir assumed in this analysis, this saving would be trivial in comparison to the cost of additional wells if the time for depleting the reservoir were not to be greatly extended.

These analyses are based on the expressions developed by Muskat[8] for the relation between the reservoir volume of gas injected and the fraction of reservoir gas in the produced fluid, and between the reservoir volume of gas injected and the reservoir volume swept, for reservoirs with exponential permeability variation. In these equations the permeability variation, expressed as the ratio of maximum to minimum permeability, and the areal sweep efficiency appear as independent variables. Sweep efficiency is defined as the fractional part of a layer of uniform permeability having the same dimensions as the reservoir that would be swept at the time of first break-through of injected gas, with same distribution of injection and production as is applied to the actual reservoir. The relation between volume of gas injected, fraction of original gas in the produced fluid and the reservoir volume swept calculated from these equations is shown on Fig. 9, for sweep efficiencies of 0.75 and 0.90, and for permeability variations of 10 and 100. It will be noted that if the cycling program is to be continued until the produced gas contains only a small fraction of the original reservoir fluid, neither the reservoir volume swept nor the composition of the produced gas is much affected by the areal sweep efficiency.

Composition of the original reservoir fluid and the pressure at which cycling is carried out determine the economic value of the undiluted reservoir gas. A significant factor in determining the value of the produced gas, particularly

TABLE 3. Division of the original well fluid into commercial products for which definite prices can be assigned.

Component	Well fluid		Condensate		Wet gas	
	Bbl/MMCF	MMCF/MMCF	Liq frac	Bbl/MMCF	Bbl/MMCF	MMCF/MMCF
C_1	.....	0.7500	.....	.....	.....	0.7500
C_2	.....	0.0800	.....	.....	.....	0.0800
C_3	26.18	0.0400	.....	.....	26.18	0.0400
C_4	26.69	0.0350	.....	.....	26.69	0.0350
C_5	17.39	0.0200	0.0250	2.06	15.33	0.0176
C_6	19.50	0.0200	0.1250	10.30	9.20	0.0094
C_7^+	70.05	0.0550	0.8500	70.05	.....	.....
Total C_3^+	159.81	0.1700	1.0000	82.41	77.40	.....
Total	.....	1.0000	1.0000	82.41	.....	0.9320

Component	Gasoline		Plant efficiency	Recoverable LPG	Dry gas		
	Liq frac	Bbl/MMCF		Bbl/MMCF	Bbl/MMCF	MMCF/MMCF	Mol frac
C_1	.....	.....	.....	.....	.....	0.7500	0.8701
C_2	.....	.....	.....	.....	.....	0.0800	0.0928
C_3	.....	.....	0.30	7.85	18.33	0.0280	0.0325
C_4	0.0400	1.02	0.8999	23.00	2.67	0.0040	0.0046
C_5^+	0.9600	24.53	.....	.....	.....	.....	.....
Total C_3^+	.....	25.55	.....	30.85	21.00	.....	.....
Total	1.0000	25.55	.....	30.85	21.00	0.8620	.....

Gas/condensate ratio 11,309 cu ft wet gas per barrel of debutanized condensate; γ at 3800 psia and 200 F = 242.513 standard c ft/reservoir cu ft;

Content of 1,000,000 reservoir cu ft at 3800 psia and 200 F

Reservoir fluid	242.5 MMCF
Wet gas	226.0 MMCF
Dry gas	209.05 MMCF
Recoverable propane	1,903.7 bbl
Recoverable butane	5,255.2 bbl
Natural gasoline	6,196.2 bbl
Debutanized condensate	19,988.5 bbl

1,000,000 cu ft = 178,107 bbl

$$\text{FVF condensate} = \frac{178{,}107 \text{ bbl}}{19{,}988.5} = 8.9105 \text{ reservoir bbl/bbl of debutanized condensate.}$$

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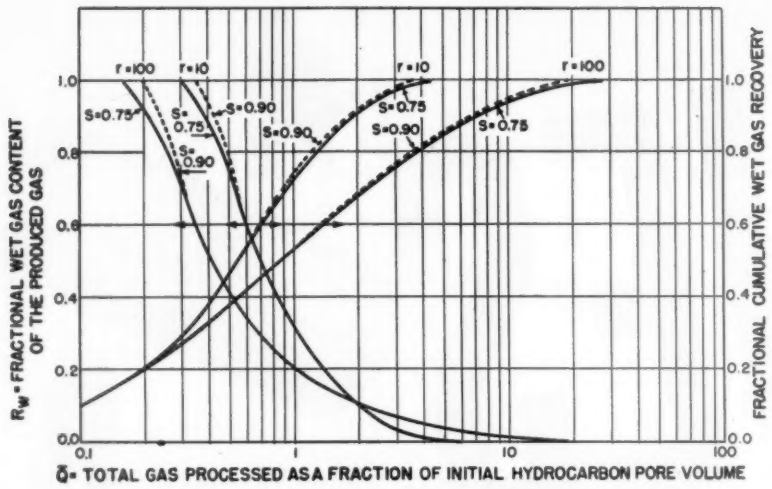


FIG. 9. VARIATION of the fractional wet gas content of the produced gas and of the total fractional wet gas recovery as a function of the reservoir volume of the gas injected in cycling operations in formations with exponential permeability variation.

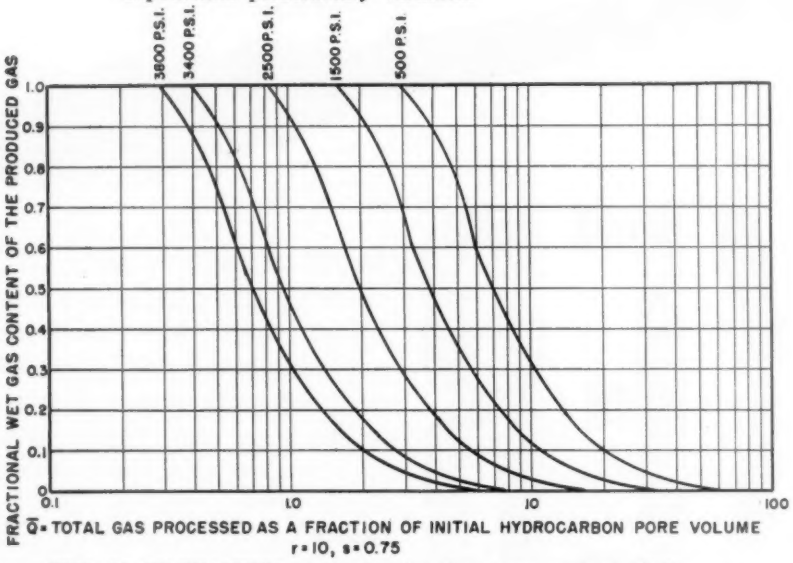

3800 P.S.I.
3400 P.S.I.
2500 P.S.I.
1500 P.S.I.
500 P.S.I.
FRACTIONAL WET GAS CONTENT OF THE PRODUCED GAS
$\bar{Q}$ = TOTAL GAS PROCESSED AS A FRACTION OF INITIAL HYDROCARBON PORE VOLUME
r = 10, s = 0.75

FIG. 10. VARIATION of the fractional wet gas content of the produced gas as a function of the reservoir volumes of gas injected for cycling at pressures below the Dew Point. Areal sweep efficiency of 75 per cent, exponential permeability variation of 10, and the well fluid of this problem is assumed.

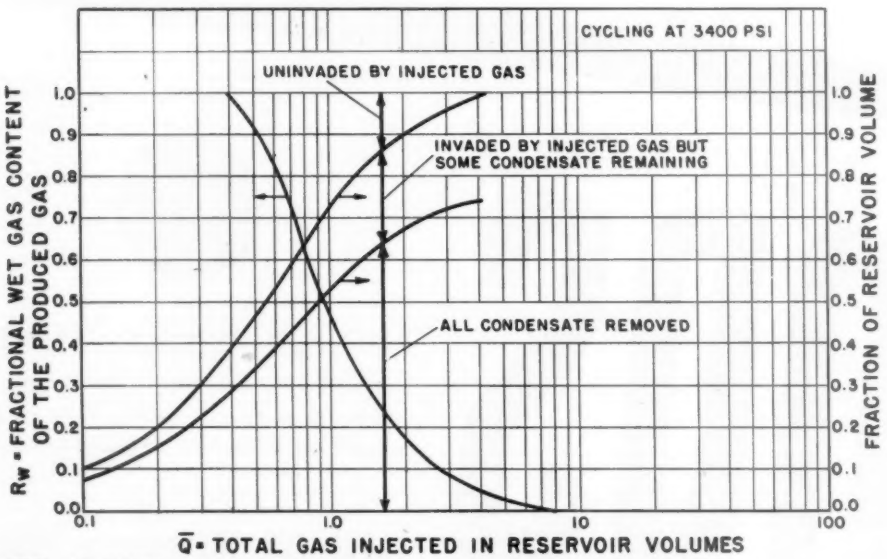

CYCLING AT 3400 PSI
UNINVADED BY INJECTED GAS
INVADED BY INJECTED GAS BUT SOME CONDENSATE REMAINING
ALL CONDENSATE REMOVED
R_w = FRACTIONAL WET GAS CONTENT OF THE PRODUCED GAS
FRACTION OF RESERVOIR VOLUME
$\bar{Q}$ = TOTAL GAS INJECTED IN RESERVOIR VOLUMES

FIG. 11. VARIATION of the fractional wet gas content of the produced gas and the fraction of the reservoir invaded and fully swept at 3400 psi as a function of the reservoir volumes of gas injected.

near the end of the cycling program, is the liquid content of the injected gas. If the gas is processed through a plant, which leaves much liquid in the injection stream, it will be economic to continue reprocessing this gas when it is mixed with only a small fraction of reservoir gas. In the analysis presented an absorber recovering only 30 per cent of the propane was assumed for all cases. The injected gas in the first stages of the cycling program contains 0.6 gpm of propane plus. At the end of the cycling program, with the plant and wells already fully depreciated, it was found to be economically feasible to continue to process a well fluid containing only a little more than 10 per cent of reservoir gas. As a result the fraction of the reservoir swept for cycling, either at the dewpoint or lower pressure, is comparatively high. It should be noted that in determining the point of abandonment, current revenue must be balanced not only against current operating costs, but also against the interest on the mar-

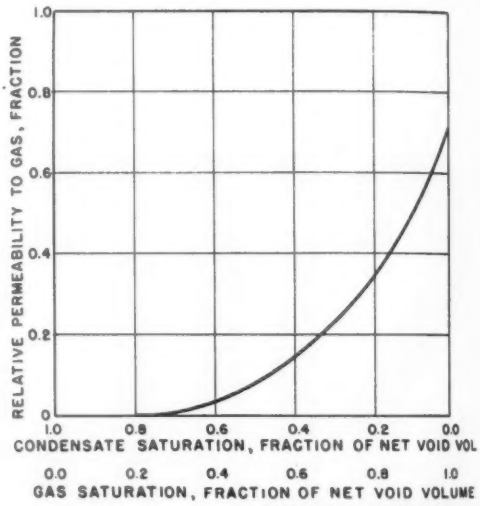

RELATIVE PERMEABILITY TO GAS, FRACTION
CONDENSATE SATURATION, FRACTION OF NET VOID VOL
GAS SATURATION, FRACTION OF NET VOID VOLUME

FIG. 12. RELATIVE permeability to gas as a function of gas saturation.

ket value of the gas, the sale of which is being deferred.

There are then at least three factors, within the control of the operator, which significantly affect the ultimate profit from the exploitation of a condensate field. The field can be depleted from the beginning or cycled at any pressure. In each case there is an optimum plant size, and the third factor is the degree to which the gas is stripped. There are probably some situations in which it would be most profitable to recover only the condensate with ordinary separators, or with simple compression and refrigeration systems, returning the gas "wet" to the reservoir, during the period of cycling, and recovering the gasoline and light hydrocarbon liquids with an absorption plant during the period of blowdown.

The content of mixtures of dewpoint reservoir fluid with various proportions of injected gas was calculated. For application to the curves for reservoir be-

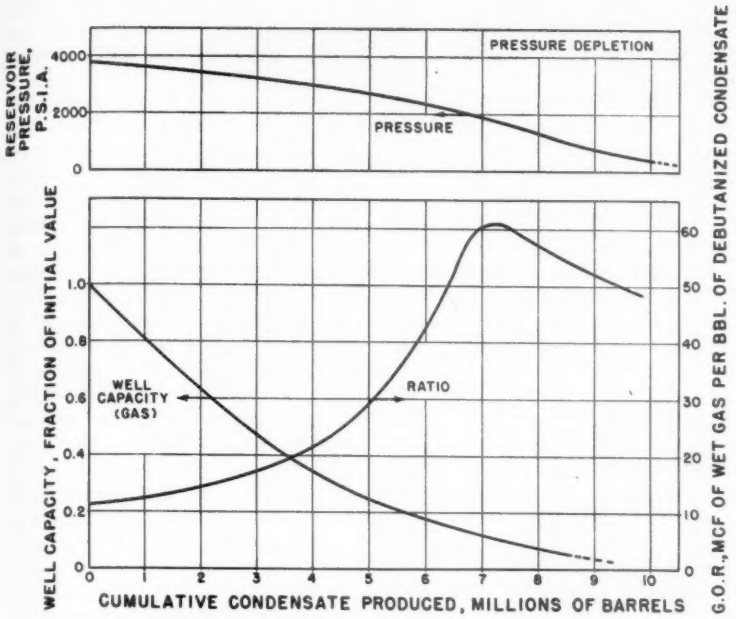


FIG. 13. VARIATION of pressure, gas/condensate ratio, and relative well capacity as functions of cumulative condensate recovery for pressure depletion of the reservoir without cycling.

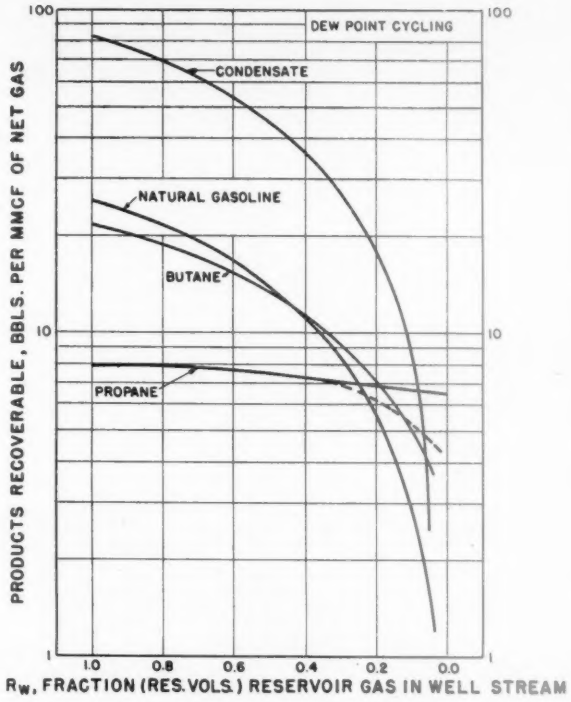


FIG. 14. COMMERCIAL products per million cubic feet of separator gas as a function of the fraction of wet gas in well stream. Dew Point cycling.

havior the proportions must be in terms of reservoir and not standard volumes. And for economic analysis the content must be in terms of commercial products not molecular constituents. For the period prior to dry gas break-through the composition of the injected gas does not change. After injected gas appears in the well stream the gas for injection contains increasing volumes of reprocessed gas. Since the viscosities of all the gases are considered uniform, the curve describing the displacement of original reservoir gas by the first injected gas also applies to the displacement of the combined original gas and injected gas by injection gas of a different composition. For the assumed areal sweep of 75 per cent and the permeability variation of 10 the reprocessed gas does not appear in the well stream until the reservoir volume of all gas injected is more than 60 per cent of the volume of the reservoir and its presence becomes important in reducing the richness of the well stream only at the very end of the cycling. But at the end of the cycling the gas in the reservoir to be recovered during blow-down contains less propane than the first gas injected.

Fig. 14 shows the commercial products that can be extracted from the well fluids as a function of the reservoir volume fraction which is original reservoir gas. The solid line for the propane is on the basis of a constant composition of

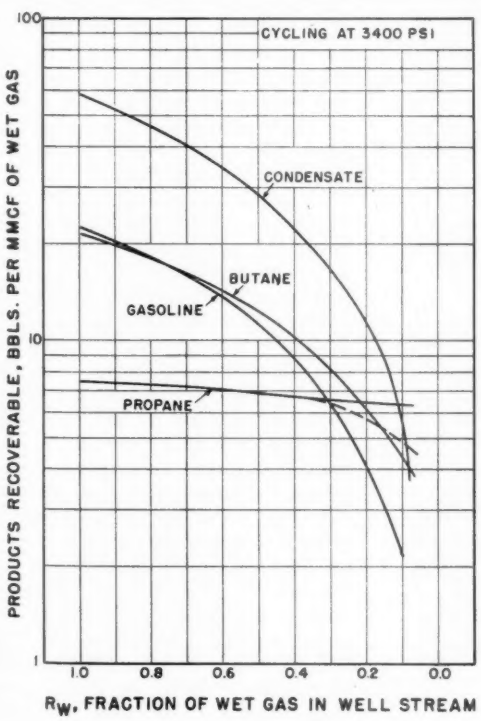


FIG. 15. COMMERCIAL, left, products per million cubic feet of separator gas as a function of the fraction of wet gas in the well stream. Cycling at 3400 psi.

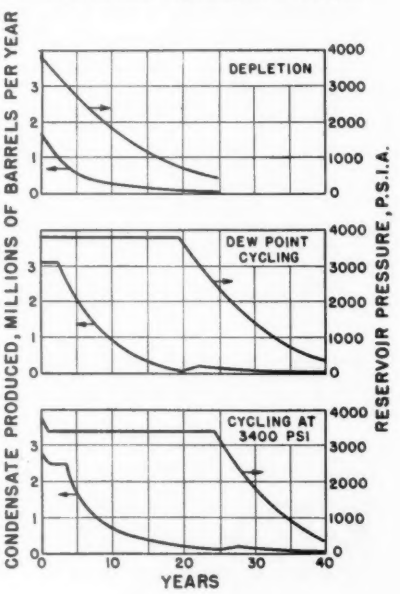


FIG. 16. RESERVOIR pressure and condensate production by years; pressure depletion; Dew Point cycling; cycling at 3400 psi.

the injected gas, the dotted line shows the effect of the change in the composition due to the fact that part of the gas has been through the absorber more than once. As the injected gas never carries any pentane and very little butane, the content of gasoline and condensate is unaffected by changes in composition of the injected gas and the effect on the recoverable butane is negligibly small.

In dewpoint cycling the capacity of the wells during the cycling period does not decline. A compressor and gas processing plant capable of handling 90,000,000 cu ft of wet gas per day was used. This has an economic life of around 30 years. The figure is approximate because no exact analysis of the time distribution of the production during the period of blow-down was attempted. To this extent the present worth of the net recovery in the economic analysis is also approximate. Twenty-two production wells were needed to load the plant.

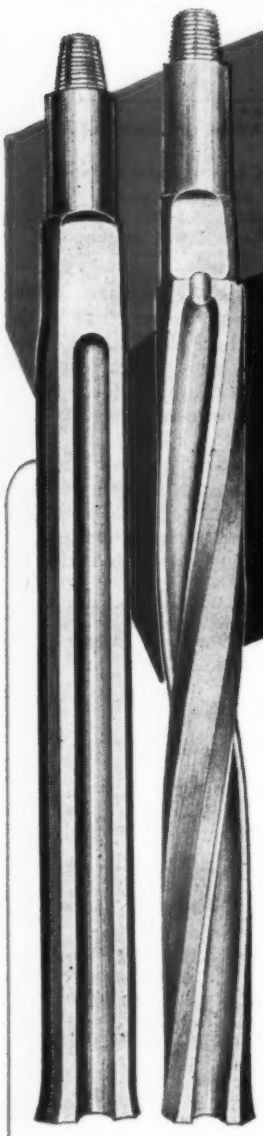
The commercial products produced in each year during cycling were calculated by determining the reservoir volume filled with injected gas at the end of the preceding year. From the two curves of Figs. 9 and 14 the fraction of reservoir gas in the flowing stream and the commercial products recoverable per MCF of mixed wet gas produced can then be determined. The annual production of products was obtained by multiplying by the annual gas capacity of the plant. The recovery during blow-down is based on the recovery by pressure depletion from the unswept area plus the difference in the gas content at 3800 psi and 400 psi for the swept area and assuming no change in the gas composition.

The recovery factor for the condensate given with the economic analysis was obtained by dividing the condensate recovery, as figured above, by the condensate originally in place, the condensate in place being obtained by multiplying the reservoir volume times the volume of original reservoir gas times the condensate per unit of original well fluid. The recovery factor thus computed is less than that calculated directly from the swept volume, but the recovery of C_5+ in the gasoline and condensate combined, as determined from the pressure depletion history and taking a recovery of 100 per cent in the swept area and adding the increased production to blow-down in the unswept area, does agree satisfactorily. The effect of producing at increasing gas/condensate ratios is to remove part of the C_6 and C_5 from the condensate and increase the gasoline recovery.

The time and number of wells required to deplete the reservoir after blow-down is less than required in pressure depletion from the beginning. The capacity of wells is a little better because the flowing columns of dry gas are substantially lighter than those of wet gas. But more important, the large compressor plant, after suitable refitting, is used to accelerate the production.

It has been shown that in cycling below the dewpoint revaporization removes all of the condensed liquid from part of the swept area and changes part of the injected gas into a saturated gas having the same composition as the gaseous phase of the original well fluid at the same pressure. In effect then we have injected gas sweeping out reservoir fluid of this composition, but more than one volume of injected gas is required to expel one volume of the reservoir fluid. The curves relating volume of injected gas to fraction of the reservoir fluid in the produced gas must be modified accordingly. At 3400 psi it was found that 0.35 reservoir volumes of dry gas were required to vaporize the liquid accumulated while the pressure fell from 3800 psi to 3400 psi. The well fluid flowing out of a single uniform stratum with 100 per cent sweep efficiency would then change from wet to dry gas when 1.35 reservoir volumes of dry gas had been injected. For 10 permeability variation and 75 per cent areal sweep the curve relating volumes of gas injected to reservoir gas in the well stream can be applied if it is modified so that the volume of injected gas corresponding to any fraction of reservoir gas in the well fluid is 1.35 times as much as in dewpoint cycling. The fractional reservoir volume which some dry gas has entered has the same relation to the total volume of gas injected as the area swept in dewpoint cycling. The volume from which

Here's why-



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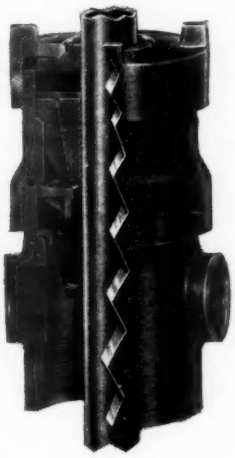

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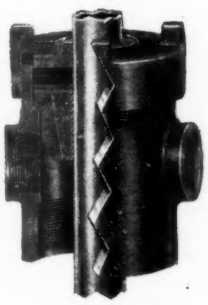

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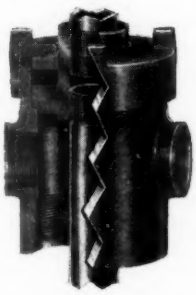

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all the condensate has been removed is

$$\frac{1}{1.35}$$ of this volume.

The well fluid in this case is the 3400 psi saturated gas. It contains 58.00 bbl of debutanized condensate per million cubic feet compared with 82.41 per million in the original dewpoint fluid. Fig. 15 shows the content of commercial products per 1,000,000 cu ft of separator gas for various mixtures of this gas with injected gas.

When cycling becomes unprofitable and reservoir blow-down begins, a part of the reservoir has not been invaded by dry gas at all. It has, however, been depleted from 3800 to 3400 psi. The remaining production will be that available by pressure depletion from 3400 to 400 psi, assumed in all cases as the pressure at abandonment. From another part of the reservoir all condensate has been removed, the gas in place is injected gas, some of it processed more than once. The difference between the content at 3400 and 400 psi will be recovered without change in composition.

The rest of the reservoir contains a gas saturated at 3400 psi and the reservoir temperature and a liquid, varying in volume from all that would accumulate in depletion of the original fluid from original pressure to 3400 psi at one edge to nothing at the other. This gas is all retrograde gas and part of the vapor phase will condense as the pressure is reduced. The recovery, which can be calculated from the equilibrium constants by dividing the partially swept volume into segments for which uniform average compositions are assumed, is nearly the same as that for the saturated gas in the wholly uninvaded volume in the same pressure interval. In some cases, the assumption that only pressure depletion recovery would be obtained during blow-down from the wholly uninvaded part of the reservoir and from the volume invaded but still containing some unvaporized condensate is not strictly valid. If the production during blow-down comes only from the same wells which were producers during the cycling period, there will be further sweeping, but at constantly declining pressures as the injected gas expands.

At 3400 psi the capacity of the wells to produce to a 2000 psi absorber was found to be only 42 per cent of their capacity at 3800 psi. This reduction in capacity results not only from the loss of available drawdown, a function of the difference of squares of the reservoir and well head pressures, but a significant reduction in the effective permeability of gas caused by the accumulation of condensed fluid.

The total volume of gas to be handled is greater than for dewpoint cycling. A larger plant of 105,000,000 cu ft per day capacity was used. Forty-two wells were needed to load this plant, the pressure of primary separators being 1800 psi.

The method followed in calculating the recovery of each of the molecular components by continuous removal of the gas phase has been described. Application of data thus calculated, or more often obtained by laboratory investigation of the behavior of a sample of the well fluid, to estimate cumulative recovery from condensate and other commercial products is well known. The capacity of individual wells will decline as the pressure falls, because of the change in fluid density, loss of available drawdown and the accumulation of hydrocarbon liquid, which reduces the effective permeability to gas. Declining gas phase viscosity is a partially compensating factor. In lean condensate reservoirs with low intersitial water the decline in effective permeability may be very small. For the present investigation, the relative permeability relations assumed, with the other factors, give a pronounced reduction in well capacity as the reservoir pressure declines, and the decline in rate of gas production or the cost of additional wells necessary to maintain a given rate is a major economic disadvantage of pressure depletion as compared to cycling at higher pressures.

The relation of the gas/condensate ratio to the condensate recoverd by pressure depletion is shown in Fig. 13. The total volume of gas to be processed is less than half of that to be handled in a cycling operation. An absorber plant of 50,000,00 cu ft per day was selected. The productive life for a plant of this size is only a little more than 17 years

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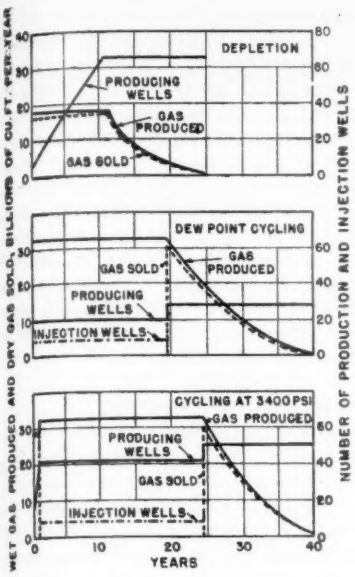

FIG. 17. GAS production, left, and number of producing and injection well by years; pressure depletion; Dew Point cycling; cycling at 3400 psi.

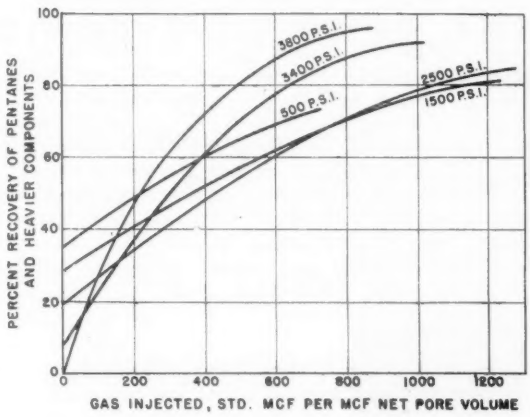

FIG. 19. CUMULATIVE recovery of pentanes and heavier as a function of volume of gas injected for Dew Point cycling (3800 psi); cycling at 3400 psi; cycling at 2500 psi; cycling at 500 psi.

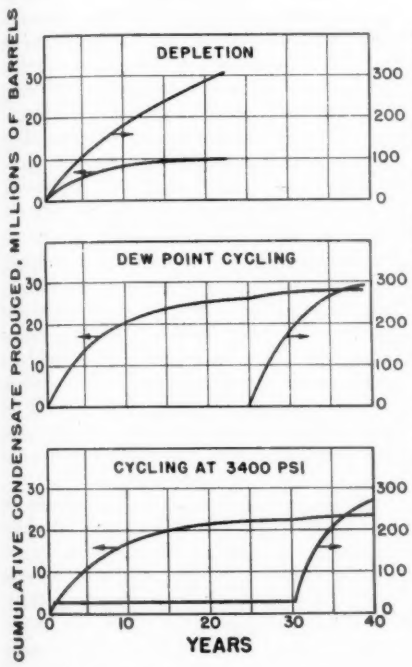

FIG. 18. CUMULATIVE condensate production and cumulative dry gas sold by years; pressure depletion; Dew Point cycling; cycling at 3400 psi.

and drilling to 40 acre spacing is required to maintain productive capacity to keep it loaded during the first 10 years. Cost of building and operating a smaller plant would, however, be only slightly less. The history of condensate production and wells on production is shown on Figs. 16 and 17.

This history of the reservoir thus developed is inaccurate to the extent that the effect of permeability variation and pressure drawdown has not been considered. For actual reservoirs, except those with very high or nearly uniform permeability as produced at very slow rates, the gas-condensate ratio will rise more abruptly. The more permeable zones will be at advanced stages of depletion when recovery from the tightest zone has only begun. At abandonment the wells may fall to uneconomic rates while parts of the reservoir still contain condensate, which, from consideration of the fluid behavior alone, would be considered recoverable.

The cas of cycling at 500 psi was not investigated in complete detail. The history and economics are identical with those for pressure depletion until the reservoir is aproaching abondonment. This type of operation is a true "secondary recovery" operation, which follows near exhaustion by pressure depletion.

The well fluid at 500 psi is decidedly "lean" and becomes too poor to process when it still contains a relatively high proportion of reservoir gas. Accordingly, the recovery of condensate is proportion-

TABLE 4. Schedule of prices.

Dry gas	10 cents per MCF
Propane	$1.26 per bbl, 3 cents per gal
Butanes	$3.00 per bbl, 7.14 cents per gal
Natural gasoline	$3.50 per bbl, 8.33 cents per gal
Debutanized condensate	$3.10 per bbl

TABLE 5. Comparative economics of dew point cycling, cycling at 3400 psi, cycling at 500 psi, and pressure depletion.

	Dew point cycling	Cycling at 3400 psi	Cycling at 500 psi	Pressure depletion
Condensate recovery factor, per cent	87.2	72.5	55.0	30.0
Condensate recovered, millions of barrels	27.9	23.2	17.6	9.6
Dry gas sold, billions of cubic feet	28.19	27.47	25.05	30.38
Years of operation	38.2	40.0	50.+	22.6
	All values in thousands			
Income before royalty				
Condensate $3.10/bbl	$ 86,490	$ 71,920	$ 54,560	$ 29,760
Dry gas at 10 cents/MCF	28,190	27,470	25,050	30,330
	$114,680	$99,390	$79,610	$60,090
Gasoline and lpg as gas at 10 cents/MCF	$1,605	$1,767	$1,830	$1,171
Subject to production tax and depletion allowance	$116,285	$101,157	$81,440	$61,261
Gasoline and lpg as liquids	71,920	68,175	70,595	44,140
Total income before royalty	$186,600	$167,565	$150,205	$104,230
Income after royalty				
Subject to production tax and depletion allowance	$101,749	$88,512	$71,260	$53,603
Total income after royalty	$163,275	$146,619	$131,429	$91,201
Production tax 4 per cent	$ 4,070	$ 3,540	$ 2,850	$ 2,144
Operating expense	20,800	20,830	35,500	10,300
Intangible drilling	2,300	4,010	6,140	6,000
Total direct expense	$27,170	$28,380	$44,490	$18,444
Depletion allowance	$26,455	$23,456	$18,171	$13,937
Depreciation	7,500	8,650	9,800	6,540
Overhead	2,441	2,030	1,540	840
Interest at 3% on unrecovered investment	404	150	135	121
Total deductions	$36,800	$34,286	$29,646	$21,438
Taxable income	$126,475	$112,333	$101,783	$69,763
Income tax 54 per cent	$68,296	$60,660	$54,963	$37,672
Direct expense	27,170	28,380	44,490	18,444
Interest	404	150	135	121
Overhead	2,441	2,030	1,540	840
Total expense	$98,311	$91,220	$101,128	$57,077
Investment — wells tangible	$1,350	$2,340	$3,300	$2,640
Gasoline and stabilization plant	4,000	4,270	5,000	3,600
Compressor at $300/hp	3,000	3,000	2,500	600
Total investments	$8,350	$9,610	$10,800	$6,840
Salvage	850	960	1,000	300
Net investment	$7,500	$8,650	$9,800	$6,540
Cash outlay	$105,811	$99,870	$110,928	$63,617
Net cash gain	$57,464	$46,749	$20,501	$27,584
Present value at 6 per cent	$31,484	$21,468	*	$15,242

* No estimate made of recovery by years.

ately low. In actual laboratory studies of some condensate fluids the gas vapor phase at pressures around 500 psi was found to be relatively richer. [9,10]

The disadvantage of this method of operation is the excessively long time required to recover the condensate, and the consequent high total operating cost. This could be shortened somewhat by providing compressors and producing the wells to very low pressures, but this increases the investment and the expense for fuel.

Summary

Several possible methods of exploiting a gas-condensate reservoir have been investigated with a hope of determining the most economical method. Although a hypothetical reservoir was assumed, it is typical of several existing condensate fields. The principle of expotential permeability stratification has been applied to the determination of recoveries during the cycling programs.

Three possible methods of exploitation were investigated in detail: (1) cycling at the dewpoint until handling of the well fluid became unprofitable followed by "blow-down" to abandonment; (2) pressure depletion from 3800 psi to 3400 psi, cycling at 3400 psi, and finally "blow-down" to abandonment; and (3) pressure depletion from the beginning. Cycling at 500 psi was investigated but without estimating recovery by years. The economics of cycling in the pressure range between 3400 psi and 500 psi was not investigated in detail. The results for the specific reservoir of this problem and the various assumptions made indicated that dewpoint cycling would be most profitable. However, it is quite likely that for a different reservoir, different prices, and different conditions than assumed here, the results could be entirely changed. It is therefore concluded that each case should be investigated separately to determine the most economical method of exploitation.

Conclusions

For the particular reservoir and the conditions assumed, dewpoint cycling is the most profitable method of exploitation. For a sufficiently high price for gas with respect to the condensate and gasoline, either pressure depletion or low-pressure cycling would be more attractive. For this particular reservoir, the data presented in Table 2 and on Fig. 8 would seem to eliminate cycling at intermediate pressures as the most profitable procedure for all ranges of prices anywhere near those assumed. In intermediate-pressure cycling a part of the gas revenue is realized early. The revenue from the condensate and the revenue from the remainder of the gas is delayed in comparison to dewpoint cycling. This delay could be avoided by increasing the plant capacity and the number of wells. With sufficiently higher prices for both gas and liquid products without comparable increase in drilling or construction costs this would be profitable. For the reservoir of the present problem the necessary price increases are quite improbable.

This investigation has led only to the conclusion expressed by others who have investigated similar problems.[11] No general rules can be given as to the most profitable method of cycling condensate reservoirs. Each case must be investigated, and major changes in relative prices for gas and condensate will usually call for revision of programs in operation or contemplated.

Acknowledgements

The authors wish to acknowledge the helpful discussions and suggestions of Dr. Morris Muskat throughout this project, and the help of Miss M. O. Taylor in making many of the lengthy calculations.

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Triangulation Method for Determining

Collapse Change Points in Casing Design

Suggested procedure eliminates complex calculations and provides rapid selection tool for ordering string

R. L. KASTOR

This paper presents a method for expeditiously and economically determining collapse change points in a manner adaptable to conventional calculation methods. The method is a graphical solution obtained by constructing a triangle defined by the pressure and tensile loading unique to each particular section of the casing design. Experience indicates considerable reductions in the amount of time required to design casing strings are possible.

THE adoption of combination weight casing strings soon introduced the problem of determining collapse change points in casing strings. This problem stems from the accepted theory of failure by yielding, which indicates the resistance of a tube to collapse is reduced by tensile stress. There have been extensive writings in the past dealing with solutions to this problem.

The determination of the change points is illusive because the collapse resistance of a particular casing is dependent upon tensile stress. Since the collapsing pressure is also a variable with depth, the problem resolves to determining a particular depth at which the collapse resistance, including the allowance of a suitable safety factor, is equal to the collapsing pressure. The collapse resistance is an elliptical function making the solution mathematically rather complex.[1]

The Author

R. L. Kastor, mechnical engineer for the Shell Oil Company in the New Orleans office, was graduated from Ohio State University in 1950, receiving a bachelor's degree in mechanical engineering and a master of science in mechanical engineering at that time. He was first employed by Shell in the Houston office. After completing a year in the company training program, he was assigned to the production division in New Orleans, where he has had considerable experience in casing design and selection operations.

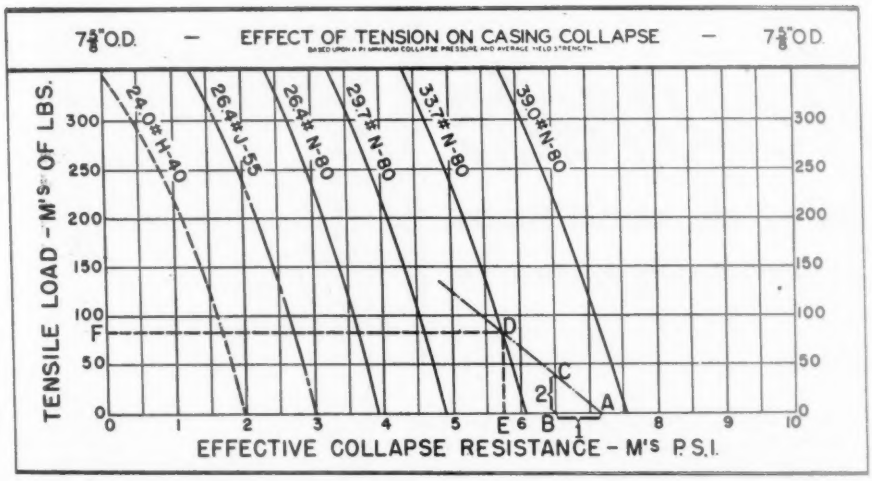

FIG. 1. CONSTRUCTION of triangle. Point A—Hydrostatic pressure of drilling fluid at bottom of casing string. Leg 1 — Magnitude of reduction in hydrostatic pressure due to a 1000-ft rise in hole. Point B — Hydrostatic pressure 1000 ft above Point A. Leg 2 — Magnitude of weight of 1000 ft of bottom section of casing. Point C — Weight of 1000 ft of casing. Point D — Collapse change point. Point E — Collapse change depth in hydrostatic pressure (divide by pressure gradient in psi/ft of drilling fluid to determine depth in feet). Point F — Total weight of casing suspended below change point (Useful as check).

Several methods for determining collapse change points have been proposed. As indicated previously, the mathematical method is complex and time consuming. More recently, a method has been presented which requires a special chart[2] for solution, and there are undoubtedly other methods in use. Of those methods which have been investigated, some difficulty has always been encountered which has prevented the adoption of the method in place of the conventional, time-consuming trial and error method. Therefore, the need for a faster technique adaptable to conventional calculation methods has remained.

Such a method has been developed and is now presented.

Triangulation Method

The Triangulation method is a graphical solution to the problem. The basic tools required are a chart of curves of the variation of collapse resistance with tensile load, such as are available in almost any casing manufacturer's engineering data book.[3] Briefly, the problem resolves to determining the intersection of two curves, one of which varies linearly, while the other approximates a portion of an ellipse. The linear curve relates the variation of hydrostatic pressure with hanging load, while the elliptical curve relates the variation of collapse resistance with hanging load. The technique is based upon the fact that both of the curves vary with the same physical parameters—pressure and weight. By plotting a linear curve of the variation of hydrostatic pressure with hanging load on the same chart with the curves of the variation of collapse resistance with tensile load, the collapse change points may be determined from the intersection of the two curves. The problem, of course, is to determine the intercept and slope of this linear curve.

Construction of the Triangle

The intercept of the linear curve with the pressure axis is readily deter-

mined since the hanging load is zero at the bottom of the string and the hydrostatic pressure equals the drilling fluid pressure gradient times the depth.

Slope of the linear curve depends on the weight of drilling fluid in the hole and the weight per foot of the casing below the change point being determined. Therefore, the slope may be established by determining and plotting the magnitude of the perpendicular legs of a right triangle and connecting the extreme ends of those legs.

The magnitude of the horizontal leg is taken equal to the decrease in hydrostatic pressure in a 1000-ft rise in the hole. The leg is plotted from the intercept point described above.

The magnitude of the vertical leg is taken equal to the weight of 1000 ft of the weight casing in the string immediately below the change point being determined. This leg is plotted from the opposite end of the previously designated leg of the triangle.

By connecting the extreme ends of these legs, the slope of the linear curve applicable to that particular section of the string is established. The intersection of the linear and elliptical curves defines the change point in terms of hanging load and hydrostatic pressure. The depth in feet may easily be determined by dividing the hydrostatic pressure by the pressure gradient of the drilling fluid.

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A Design Example

The technique may be most readily illustrated by the use of a design example. As this example is to illustrate only the method of designing for collapse, the upper portion of the string, which is controlled by tension and burst, will not be considered.

Assume it is necessary to design an 11,000-ft, 7⅝-in. protective casing string to set in 12.5 lb per gallon drilling fluid maintaining a minimum conventional collapse safety factor of 1.00. (It is possible to apply any collapse safety factor by using an equivalent mud weight determined as the product of the actual mud weight and the desired safety factor for collapse.)

The hydrostatic collapsing pressure at the bottom of the hole is, therefore, 11,000 ft by .650 psi ft or 7150 psi, assuming zero internal pressure.

From API minimum values, it is found that 39.0 lb per ft N-80 casing having a tabulated collapse resistance of 7530 psi is required at 11,000 ft.

The resulting collapse safety factor is 7530 divided by 7150 or 1.05.

To determine the depth at which 33.7 lb per ft N-80 will set with a collapse safety factor of 1.0 by the Triangulation method, proceed as follows:

1. Establish Point A, the collapse pressure at 10,000 ft at zero tensile load.
   Abscissa = 7150 psi
   Ordinate = -0- lb
2. Establish Point B, the collapse pressure at 10,000 ft (or 1000 ft up the hole).
   Abscissa = 7150 — 650 = 6500 psi
   Ordinate = -0- lb
3. Establish Point C, the tensile load hanging below the 10,000-ft depth (or 1000 ft up the hole).
   Abscissa = 6500 psi
   Ordinate = 1000 (39.0) = 39,000 lb.
4. Connect Points A and C with a straight line and extend the line, if necessary, to intersect the collapse resistance curve for 33.7 lb/ft, N-80 casing at Point D.
5. Read the coordinates of Point D.
   Abscissa = 5730 psi
   Ordinate = 85,000 lb
6. Convert the abscissa of Point D to feet by dividing by the drilling fluid pressure gradient.
   5730 psi divided by .650 psi/ft = 8820 ft

This is the depth at which 33.7 lb/ft N-80 casing will set with a collapse safety factor of 1.00, including the effect of tension on collapse.

7. Check the solution by determining the weight of 39.0-lb casing hanging below 8820 ft.
   11,000 ft — 8820 ft = 2180 ft
   2180 ft by (39.0 lb/ft) = 85,000 lb

Thus the solution checks with the ordinate of Point D.

To determine the depth at which 29.7 lb/ft N-80 will set with a collapse safety factor of 1.0 by the Triangulation method proceed as follows:

1. Establish Point A′ equal Point D.
   Abscissa = 5730 psi

Ordinate = 85,000 lb

2. Establish Point B′, the collapsing pressure at 7820 ft (or 1000 ft above the first change point)
   Abscissa = 5730 — 650 = 5080 psi
   Ordinate = 85,000 lb
3. Establish Point C′, the total tensile load hanging below the 7820-ft depth (1000 ft up from Point D)
   Abscissa = 5080 psi
   Ordinate = 85,000 + 1000 (33.7) = 118,700 lb
4. Connect Points A′ (D) and C′ and extend the line to intersect the 29.7 lb/ft N-80 curve at Point D′.
5. Read the coordinates of Point D′.
   Abscissa = 4270 psi
   Ordinate = 160,800 lb
6. Convert the abscissa of Point D′ to feet.
   4270 psi divided by .650 psi/ft = 6570 ft.

This is the depth at which 29.7 lb/ft N-80 casing will set under the above conditions.

7. Check the solution by determining the total weight of the casing hanging below the 6570-ft depth.
   8820 ft — 6570 ft = 2250 ft
   2250 ft (33.7 lb/ft) = 75,800 lb
   85,000 + 75,800 = 160,800 lb

Thus, the solution checks.

The above-described procedure would then be repeated until no further collapse change points need be determined. In the example, this would probably occur with the change to 26.4 lb/ft N-80 since the use of 26.4 lb/ft J-55 casing probably would be precluded by tensile or burst requirements.

The method may be used when it is necessary to transfer from one chart to another by relocating the last used Point D, relabeling it Point A and establishing the related points B and C on the new chart.

Acknowledgment

The author wishes to extend his appreciation to W. R. Cox who suggested the technique for incorporating safety factors other than 1.0 and to his colleagues in the mechanical engineering section for their valuable assistance. Appreciation is also extended to the Spang-Chalfant Division of The National Supply Company for permission to reproduce material and to the management of the Shell Oil Company for permission to publish this paper.

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*Presented at the Petroleum Mechanical Engineering Conference of The American Society of Mechanical Engineers, Houston, Texas, September 28-30, 1953.

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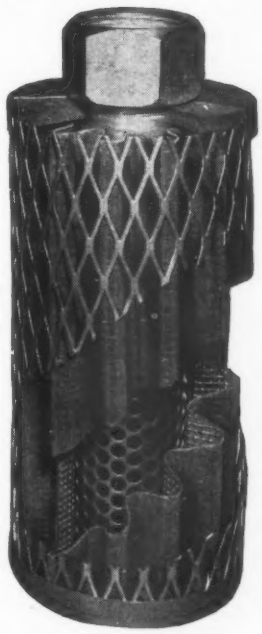

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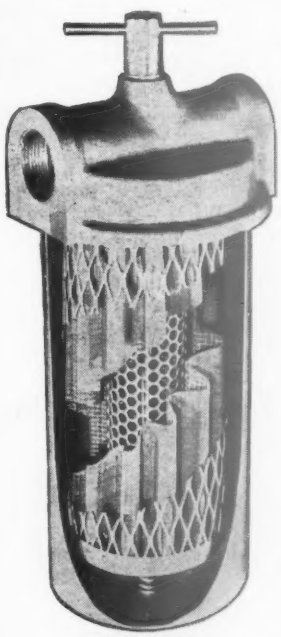

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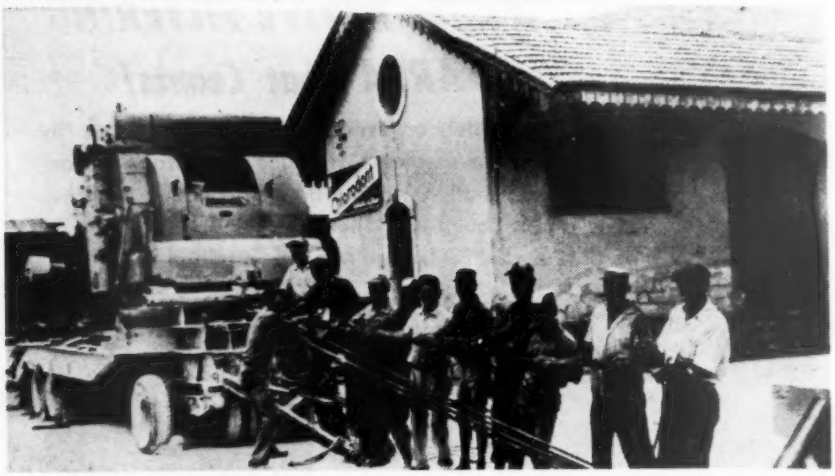


TEST WELL IN SICILY. Drilling has commenced at Vittoria, Southern Sicily where the D'Arcy Exploration Company, Anglo Iranian's prospecting subsidiary, has a concession area. Photograph shows winching gear arriving at Vittoria enroute to the drilling site.

Lumb, Marshall Head Northern Natural Offices

Northern Natural Gas Producing Company has opened a new district office in Billings, Montana, in the Ryniker Building at 7 North 33rd Street. It will be known as the Billings district office and will supervise exploratory activity in Montana, North Dakota and South Dakota.

The Bismarck, North Dakota, office of the company has been closed and personnel transferred to Billings.

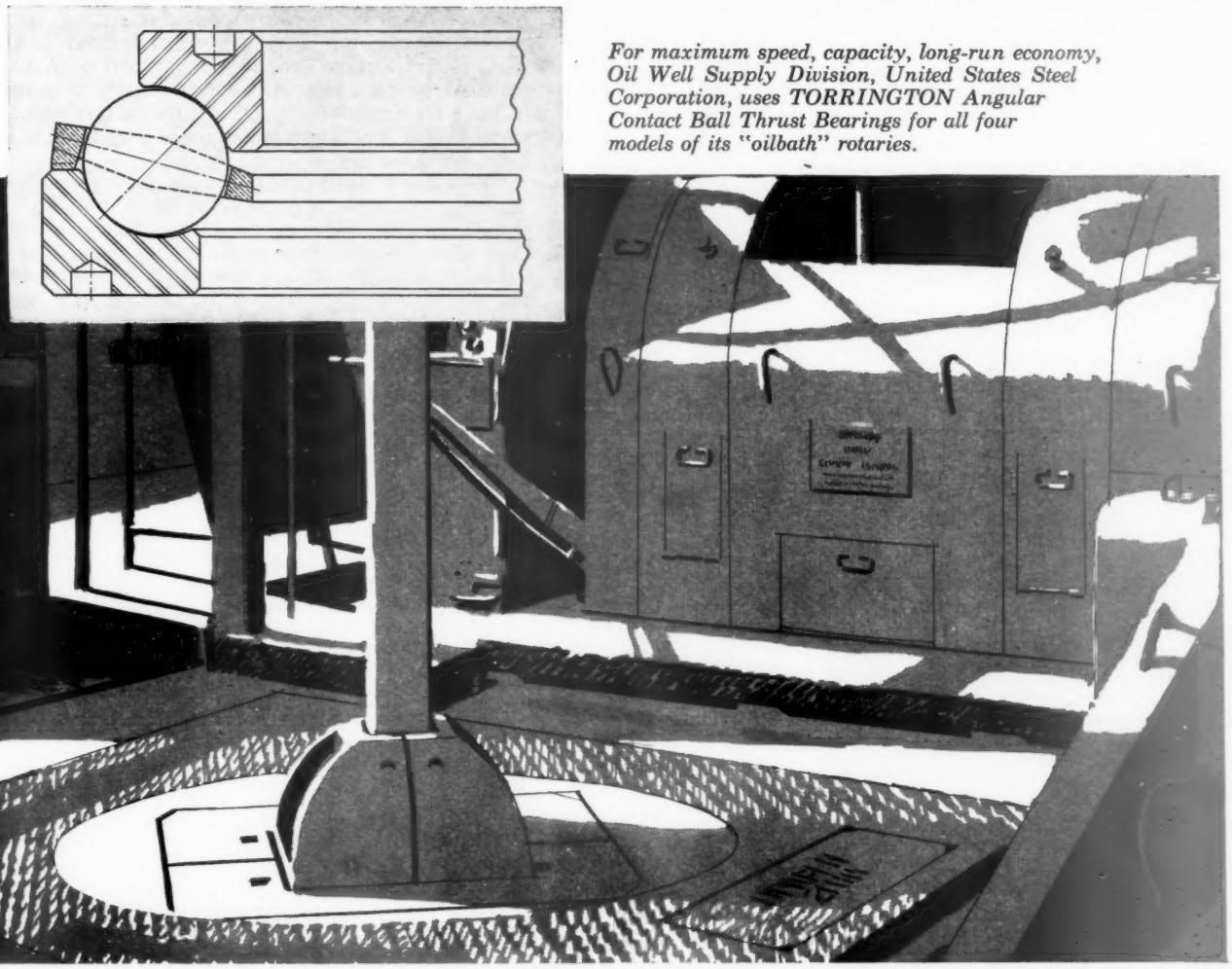
W. E. Lumb is district geologist in charge of the new office. Shirl Davis is district land man and geologists are R. V. Moore and E. K. Beekly. D. G. Mackay is scout and secretary for the office is Miss Betty Ford.

Northern Natural also has opened a new district office in Denver, Colorado, Room 622 of the Railway Exchange Building at 909 North 17th Street. The Denver office of the company will supervise gas and oil exploratory activity in Colorado, Wyoming, western Nebraska, and northwestern New Mexico.

Earl E. Marshall is district geologist in charge of the Denver office. Before being transferred to the new Denver office he was in the Omaha, Nebraska, office of the company. Marshall is a graduate of the University of Kansas, and University of Michigan, obtaining a MS degree. He is a former faculty member of the Kansas City Junior College where he taught geology.

NEW YORK Chapter of Nomads' October party was held recently, at Hotel Biltmore and was attended by 130 members and guests. A motion picture history of the Assam Oil Company, "The Digboi Story," provided by E. V. Corps, their senior geologist, was highlight of the evening's entertainment. Visitors at this party included the following: Seated: E. V. Corps, Assam Oil Company, India; G. Zalles, C.I.B.O., Bolivia; Carl Whigham, California-Texas Oil Company, Sumatra; L. P. Hulin, Hayward Tyler and Company, England; R. T. Myer, California-Texas Oil Company, England. Standing: Paul White, The Texas Petroleum Company, Venezuela; E. R. Desikan, Indian Consulate, India; Gordon Smith, Arabian American Oil Company, Saudi Arabia; M. Binet, S.N.M.A.R.E.P., France; Fritz von Estorff, Socony-Vacuum Oil Company; Jack Smith, International Cementers, Inc., California; E. C. Brown, Brown Drilling Company, California; J. David Cerkel, United States Geological Survey, Washington, D. C.

TORRINGTON BEARINGS AT WORK



For maximum speed, capacity, long-run economy, Oil Well Supply Division, United States Steel Corporation, uses TORRINGTON Angular Contact Ball Thrust Bearings for all four models of its "oilbath" rotaries.

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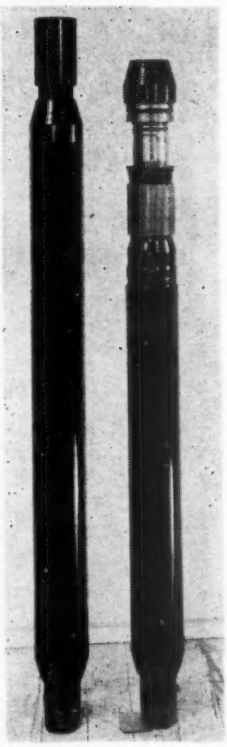
Gulf Northern Pacific To Drill North Dakota Well

LeRoy H. Hines, vice president-oil development, Northern Pacific Railway Company, announced an operating agreement with Gulf Oil Corporation in the Trotters area, Billings and Golden Valley counties, North Dakota. This area lies approximately midway between the Sun-Phillips-Dynneson well in Richland County, Montana, and the Amerada-Northern Pacific-Herman May No. 1 well in the Fryburg area, Billings County, North Dakota.

Drilling of the deep test well under the agreement will be commenced immediately in Golden Valley County.

New Gas Lift Valve Introduced



Cummings Inc. of Houston has introduced a new gas lift valve that applies a new basic operating principle to gas lift. Valve is casing pressure operated and has no moving metal parts. Its only moving part is an oil and gas resistant rubber sleeve that bends slightly to permit entry of gas into the tubing. Used in either intermittent or continuous flow, operation is determined by the gas injection rate at the surface.

The valve is run in the tubing in the conventional manner with the highest pressure valve at the top. Prior to installation, the valve pressure chambers are loaded and then sealed by the cap screw at the lower end of each valve. This loading pressure is applied underneath a rubber sleeve that seals off both the gas entrance slots of the external sleeve and the exit slots of the finned retainer.

Only 10 to 15 lb pressure increase in the casing annulus is necessary to open the valve to maximum flow port capacity. Upon reaching this pressure, the valve remains in open position until the casing pressure drops to the opening point at which time the valve snaps shut.

The gas lift valve incorporates the following features:

1. Each valve can be used for either continuous or intermittent flow.
2. No metal moving parts.
3. A very small opening and closing differential with a bubble-tight seal.
4. Extremely large flow ports can be used.
5. Valve is built *around* a full-opening mandrel, rather than alongside the tubing.
6. Check is a positive seal and does not require a velocity to close.
7. Flow ports into the tubing offset each other and angle 20 deg from the vertical, reducing cutting or washing action in the tubing and also utilizing kinetic energy of the gas.
8. In intermittent operation minimum amount of gas can be injected into the casing to lift load of fluid.
9. In continuous flow operation, expanding orifice feature of the valve eliminates the need of small orifices in the valve.

Schwab Aids in Completion Of New French Gas Well

Carl Schwab, service administrative manager of Otis Pressure Control, Inc., Dallas, arrived in Paris recently to assist the government-owned Societe Nationale Des Petroles D'Aquitaine in the completion of a high pressure gas well.

Schwab will supervise the French in the installation of various safety devices in the completion of the well. This well is in Southwestern France, and was drilled to a total depth of 12,000 ft where a high pressure formation was encountered. Well has a well-head pressure of 7000 psig and produces gas with a high percentage of hydrogen sulfide, which makes it quite poisonous. The extremely high pressure and presence of poisonous gas presented an unusual completion and production problem for the French company.

Western Opens New Station

A new technical oil well services station has been opened at Healdton, Oklahoma, by The Western Company, of Midland, Texas, it has been announced by H. E. Chiles, Jr., president. Western, according to Chiles' statement, will offer in the new area its complete line of services and products including fracturizing, acidizing, jet and bullet perforating and radioactivity well logging.

Cy V. Helm has been designated manager of the new district and will be assisted by Charles Pannill.

Geological Field Trip Held

The fourth annual field conference of the New Mexico Geological Society, was held recently. A short excursion was made to the Franklin Mountains near El Paso to examine Paleozoic rocks in that region.

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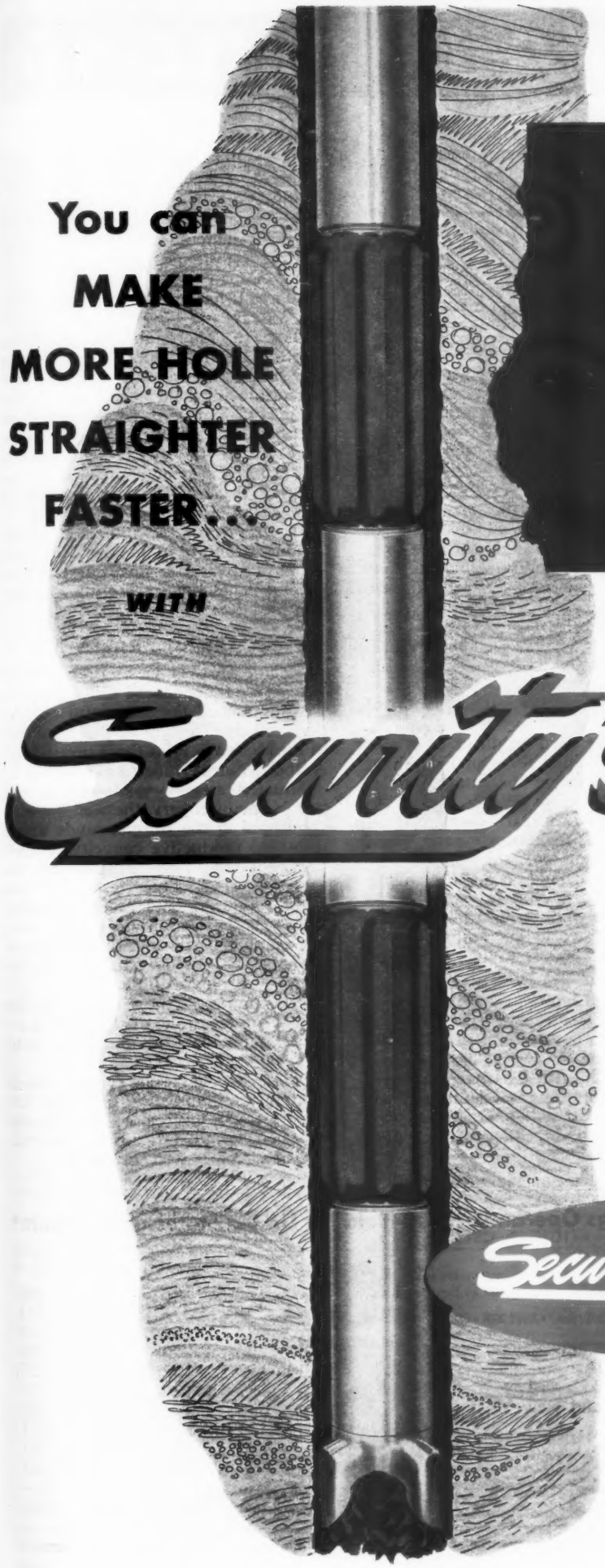

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WHAT'S DOING IN DRILLING

CANADA

★ Amerada has an indicated oil zone of 94 ft in their recent completion in Alberta's Sturgeon Lake area. The new well flowed at a rate of 470 bbl per day through a 12/64-in. choke on potential test. It extends the field 1½ miles northwest and confirms the existence of a rising reef structure trending northwestern.

★ Bishop Oil Company has announced that its fourth well on a 160-acre Crown Reserve lease in the Joseph Lake oil field of Alberta Province, Canada, has been placed in production.

The well, Decalta-Bishop No. 3, is producing 39 gravity crude at the rate of 72 bbl per day from the Viking sand at the interval from 3311 to 3316 ft.

★ British American and Cities Service have completed their Clive 5-15 well in Alberta Province, Canada, for an initial potential of 576 bbl of oil daily, to provide the Clive pool with a ¾-mile southeastern extension.

The step-out was flowing 38.8 gravity oil through various chokes from the Devonian D-3 reef limestone, topped at 6270 ft. The well is approximately 75 miles south of Edmonton.

The Clive field was discovered by British American and Cities Service.

CALIFORNIA

★ Tide Water Associated Oil Company announced the successful completion of two additional oil wells on its leases in the Ventura Avenue field, California, bringing to 306 its total current productive wells in that field.

Hartman No. 45 is flowing at the rate of 1345 bbl a day, net, of 30.1 gravity oil from a depth of 12,991 ft in the D-8 zone. It is situated approximately in central portion of the field.

The second new well, known as Ventura Land and Water Company 102, is located in the Eastern portion of the Ventura Avenue field and is flowing 666 bbl a day, net, of 33.6 gravity oil. It was completed at a depth of 11,045 ft in the D-6 zone.

★ Union Oil Company has announced completion of its Simi 9-12 well in the South Tapo area of the company's Simi Fee property for 813 bbl a day of 25.2 gravity crude oil. The well is producing from a depth of 2248 ft.

This is the ninth well Union has drilled in this Ventura County field since the initial well was completed in February. The nine wells are producing a total of 3150 barrels of crude oil daily.

★ Union Oil's Sansinena No. 8-B-1 (Los Angeles County), discovered a new Miocene pool approximately one-half mile east of the main Sansinena producing area and was completed at a depth of 5325 ft, flowing 285 bbl per day of 27.6 deg gravity oil.

★ Union's Stearns No. 130 south of Tonner Canyon area in the Br[illegible] Olinda field (Orange County), was als[o] a new pool discovery, completed in shallow Pliocene sands for 295 bbl per day of 26.5 deg gravity oil, also flowing. Stearns No. 132 extended the Tonner Canyon producing area in a northwesterly direction with initial production of 335 bbl per day.

LOUISIANA

★ A new record has been set by Shell Oil Company for deep production in its Weeks Island field, west of Franklin, Louisiana.

The company's Gonsoulin-Minvielle State Unit No. 2 well has been completed at the interval 17,260-17,306 ft, flowing 141 bbl per day of 42.5 gravity condensate and 4,293,000 cu ft of gas on a 24/64 in. choke.

With the Gonsoulin-Minvielle State Unit No. 2 well, Shell has set a second record for deep production at Weeks Island this year. Former record in the field was set by Shell's Weeks-Gall Unit No. 1, completed in March of this year, about 1000 yd from the new deep producer, at a depth of 17,122.

This latest deep producer at Weeks Island was drilled to a total depth of 18,568 ft to bring the total of miles of hole drilled at Weeks Island to more than 347. So far commercial oil and gas accumulations have been found on all of the flanks of the two-mile diameter island, at depths ranging from 2094 to 17,306 ft.

This new well brings the total of wells in the world currently producing below 15,000 ft to 11, with 9 of these in the Weeks Island field of Louisiana.

★ Warren Petroleum Corporation announces the completion of a south flank well on the Anse la Butte salt dome in St. Martin Parish. Completed through perforations at a depth of 8681 ft, initial production on the well was 451 bbl of 34 deg oil per day on a 12/64-in. choke.

ENGLAND

★ A shallow-bore drilling program to determine the underground structure in the Formby area of West Lancashire, England, has been started by Anglo-Iranian Oil Company's prospecting subsidiary, D'Arcy Exploration Company.

One test has already been completed at 900 ft and seven others will be drilled to approximately the same depth. The area being drilled is about one mile east of Anglo-Iranian's present producing field near Formby. The small but constant production from this field, and ground seepages nearby, suggest that the area is being actively fed from a deeper source. A second area to the west of Formby will be drilled later.

Owing to the complicated underground structure of the area the usual geophysical and seismic surveys have proved ineffective in plotting rock formations.

KUWAIT-SAUDI ARABIA

★ Ralph K. Davies, president of American Independent Oil Company, has announced the successful completion and final testing of the third well in the Wafra field in the Kuwait-Saudi Arabia Neutral Zone.

Situated a mile south and a mile east of the discovery, the well has been completed in the Burgan sands with a sustained productive capacity of 3000 bbl per day. This substantiates the prospect of a large reserve in the Wafra structure and confirms earlier geological and geophysical indications. The company will develop the field on a one mile spacing pattern with the fourth well now drilling.

A second rig is now enroute to the field to speed up the drilling and is expected to be in operation there in about 45 days.

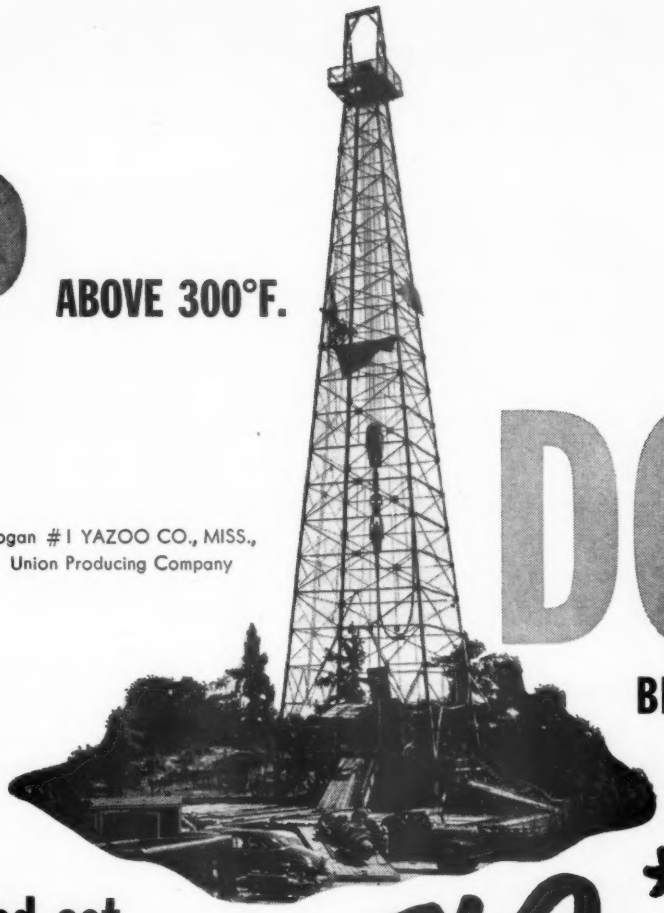
Meanwhile, all wells remain shut-in pending the completion of a pipe line to the Persian Gulf some 30 miles distant, and terminal facilities, construction of which is well advanced.

Rotary Rigs Operating in Oil Fields of United States and Canada*

	Sept. 14	Sept. 21	Sept. 28	Oct. 5	Oct. 12
Pacific Coast	173	174	176	164	166
Oklahoma	351	358	358	357	353
Kansas	154	151	161	165	163
Rocky Mountains	275	264	272	276	288
Canada	177	132	182	176	177
Ark-La-Tex	179	193	186	182	190
West Texas and New Mexico	475	486	472	490	492
Gulf Coast	501	533	540	566	575
Illinois	148	150	156	153	153
North Texas	315	308	314	326	323
Total	2748	2799	2817	2855	2880

*As reported to American Association of Oil Well Drilling Contractors by Hughes Tool Company.

UP ABOVE 300°F.



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*"*UNAFLO*" is the registered trade mark of the retarded oil-well cement manufactured by Universal Atlas Cement Company*

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Resistant to Sulfate Waters
Atlas Portland Cement—Type I

Atlas Portland Cement—Type II
Resistant to Sulfate Waters
Atlas High-Early Cement—Type III

PE-U-129 R

OKLAHOMA

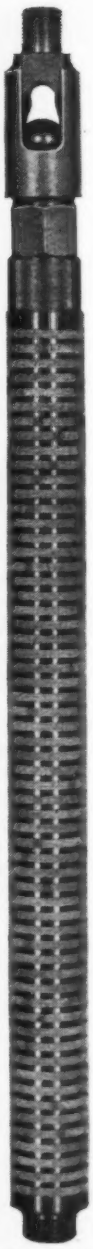
★ A new Skinner sand field has been opened in Lincoln County, Oklahoma, by Sterling Oil of Oklahoma, Inc., at their Burchette No. 1.

The new producing area is east of East Payson field. Although both the new and the old field produce from Skinner sand, the new reserve is contained in a section of the sand not present in the old field which produces from a different zone.

While cleaning out, the discovery made 30 bbl daily, no water. Following fracture treatment through perforations 4232 to 4244 ft a tubing swab gage showed 22 bbl of new oil per hour during a 24-hour test to net 528 bbl of pipe line oil per day, no water. Pumping equipment is being installed.

★ In the Osage area, the Gross Drilling Company has extended the Burbank field to the east with its completion in the Burbank sand. Initial test in this well indicated a producing potential in excess of 1300 bbl a day through 7 in. casing. Total depth drilled was 2870 ft.

★ In the Northeast Little Chief field, east of the south end of the major Burbank field in Osage County, good production has been found. It is thought that this new strike will be the best producer in the Osage reservation since before the war.



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TEXAS

★ Cities Service et al are assured of a second pay in its Payton No. 1 test, in the Payton pool of Pecos County, Texas.

On a drill-stem test in the Connell sandstone (Simpson formation) between 9815 and 9865 ft, the well flowed gas at the rate of 3,575,000 cu ft daily through a 5/8-in. bottom and a 3/4-in. top choke. The well produced 25.5 bbl of condensate per 1,000,000 cu ft of gas.

Operators are drilling ahead at 9887 ft to the Ellenburger objective.

First pay uncovered by the test was in the Devonian, when it flowed 5,000,000 cu ft of gas daily on drill-stem test from 6768 to 6800 ft. Test was through a 1/4-in. bottom and a one-in. top choke. Condensate production was at a daily rate of 115 bbl.

The well blew out late in January, when drilling crew was changing bits at a total depth of 6780 ft. It flowed uncontrolled for a week.

★ In Andrews County, Magnolia has extended the Magutex multiplay field to the northeast with the completion of the No. 1-36990 University. The Devonian producer was completed through perforations 12,528-12,541. After treatment with 6000 gal of acid, well was gaged at 210 bbl of 41.4 deg oil, no water, with a gas/oil ratio of 747-1. Tubing pressure oil flow of 30/64-in. choke was 60 lb. Test is on a 1931-acre block.

★ Also in Andrews County 3½ miles south of Andrews, Fred Turner Jr.'s No. 1 Parker has been completed as a Wolfcamp producer. Flowing potential was 348 bbl of 36.6 deg oil, no water, with a gas/oil ratio of 1201-1. Test was made on a 3/4 in. choke with production from casing perforations between 8556-8624. Five and one-half inch casing was set and cemented to the total depth of 8676.

★ Still further south of Andrews, Humble's No. 1 T University treated Wolfcamp perforations between 9050-9080 ft with 5000 gal of acid. After cleaning, the well was gaged at 383 bbl of oil in 17 hours on a 32/64-in. choke with a tubing pressure of 120 lb and a gas/oil ratio of 492-1. The well was producing some 12 per cent BS & W.

★ In Young County, Cities Service Oil Company has extended the Langston-Kleiner pool with the completion of the No. 3 Davis for an initial production of 252 bbl of oil per day. The production was from the 3rd Garvey field between 3570-3580 ft. Test was through a 24/64 in. choke.

★ On the Gulf Coast Humble has completed it's No. 1-B O'Connor as a flowing oil well. Tested on a small choke, yield was at a rate of 123 bbl per day of 36.6 deg oil. Production is through casing perforations from 5866 to 5876. The discovery is being confirmed by the almost simultaneous completion of the Chicago Corporation's Lawrence O'Connor No. 1, a north offset.

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EXPLORATION ACTIVITIES

ROCKY MOUNTAINS

★ In Colorado considerable activity in the Black Hollow area of the Denver Julesberg Basin is noted. The California Company has reported swab tests up to 30 bbl of oil per hour from its No. 1 Union Pacific Railroad in Weld County. The well confirms the Lyons sand discovery of recent months. A second off-set location is being drilled and promise for considerable additional activity is seen. Black Hollow is the second pre-cretaceous field in the Denver Julesberg Basin and apparently confirms the future importance of this horizon as a drill target.

★ The final completion of Amerada Petroleum Corporation's No. 1 May in the Fryburg area of Billings County, North Dakota, has been announced. This upper Madison discovery had an initial potential on a 18/64-in. choke of 217 bbl of 40.6 deg oil per day. Completion was from open hole from 9408-9429 ft. Now in the process of confirming the May discovery, the most significant of the Williston Basin tests off of the Nesson Anticline in the United States portion of the Basin, Amerada has tested in its No. 1 Logan, the zone from 9418-9451 ft. Reported recovery of test was 2000 ft of highly gas and water cut cushion and 1500 ft of highly oil and gas cut mud. The producing section in this well is apparently some 12 ft lower structurally than in the discovery well, but promises to make a commercial producer.

★ The Texas Company announced striking its first production in North Dakota and the opening of a new oil producing area in McKenzie County, North Dakota, 11 miles south of Beaver Lodge field, Williston Basin.

Texaco's Government-Dorough No. 1 flowed 320 bbl of 40 gravity oil and 10 bbl of water through an 18/64-in. choke on a 24-hour test. Drilled to a total depth of 8937 ft, the well was perforated from 8791 to 8866 ft in the Mission Canyon limestone. Tubing pressure was 460 lb, and a nominal quantity of gas was reported.

★ In Wyoming the Southeast Sand Draw discovery being drilled by Sohio has been completed. Producing from the Tensleep, the well gaged in excess of 400 bbl of oil daily under swab. Tests of the Phosphoria showed commercial oil and of the Frontier, 3 to 5,000,000 cu ft of gas per day. Tensleep oil gravity in this well is in the range of 22 to 23 deg.

NEW MEXICO

★ Richardson and Bass No. 1 Fidel Federal, an Eddy County venture, has been completed in the lower Delaware zone. Drilled to a total depth of 15,611 ft the well was plugged back and casing set to 11,991 ft. On test following fracture of the zone at 6890-6950 ft, the well flowed oil at a rate in excess of 45 bbl per day. Location of this indicated strike is approximately 15 miles east of Carlsbad.

★ In Lea County, Western Natural Gas Company has completed its No. 1 Edison for a daily flowing potential of 840 bbl of 60 deg oil. Test was conducted through a ½-in. choke. Production is through casing perforations in 2 intervals from 12,482-12,680 ft and test was conducted following treatment with 1500 gal of acid. Drilled to a total depth of 12,757 ft, production is from the Devonian zone which was topped at 12,475 ft. This important wildcat well is about 7 miles southwest of Lovington and is fully 10 miles from the nearest Devonian production.

EXPLORATION ROUNDUP

★ At least five developments of importance have transpired in the last month. Highlights in the exploration activities are seen in the final completion of Amerada's No. 1 May, a highly interesting test in the Fryburg area of Billings County, North Dakota, the Champlin Refining Company's No. 1 Dyer, a promising discovery in Wood County, Oklahoma, several important Ellenburger openers in West Texas, and the announced completion of a joint venture in which Gulf Oil Corporation is the operator in Florida. This latter activity promises the opening of a new Sunniland promising structure and is of great importance to the state. Activity in Colorado has continued on a relatively high plane. Of particular interest was the discovery of more than 50 ft of saturation in the Permian Age Lyons sand in the Black Hollow area.

CALIFORNIA

★ Interesting developments in California have included numerous important extensions to the known fields. In the area of new discoveries, the General Exploration Company has completed a wildcat test near Bandini one mile west of the East Los Angeles field. The new well, the No. 1 CCMO, flowed at an indicated rate of 500 bbl of 38 deg crude per day. Production, controlled by an 18/64-in. choke, was from perforations in the interval 6277-6317 ft.

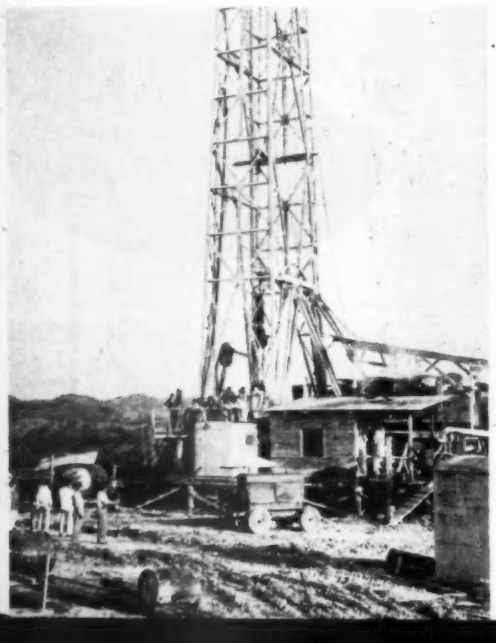
★ The Standard Oil Company appears to have brought in a new pool in the Edison area of Kern County. While testing the interval 5916-36, the 47-A Jeppi-Camp flowed at an estimated 500 bbl per day rate producing 42 deg. Although the wildcat is within ½ mile of a Pyramid Hills producer that had an initial production for 300 bbl a day on completion last year, the Torey Canyon field of Ventura County has proved productive in the Eocene section through completion of Union Oil Company's No. 92 Torey. Perforated liner was landed at 14,989 ft with production from intervals 12,737-13,479 and 13,989-14,888 ft.

OKLAHOMA

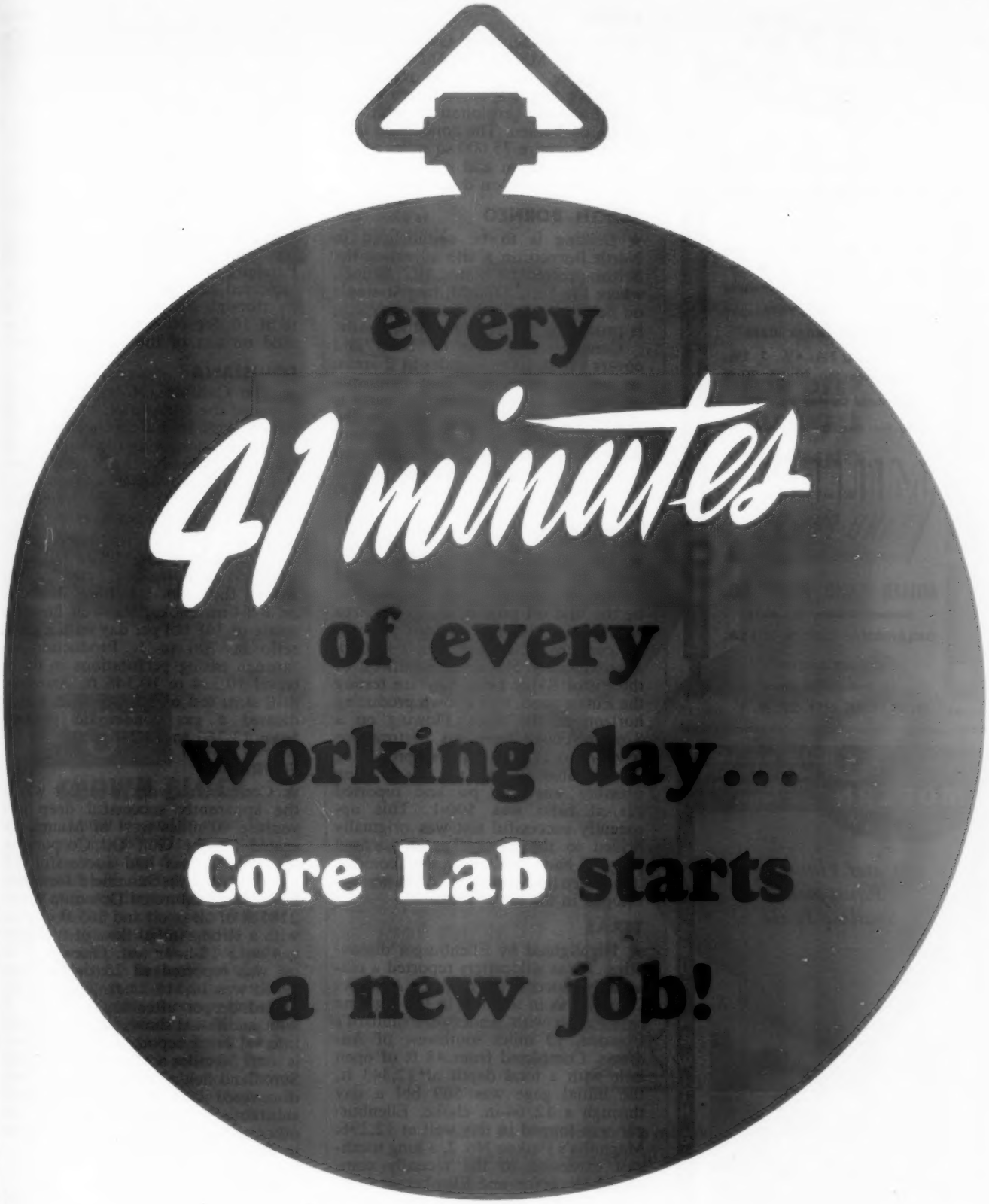
★ The Champlin Refining Company's No. 1 Diamond on the Northern Shelf of the Anadarko Basin in Woods County has an apparently significant well in the Arbuckle. Testing the interval 6110-6113 ft, live gas surfaced in 13 min and oil in 5 hours. Well was flowed for 7 hours and produced 24 bbl of 43 deg oil with a surface flowing pressure of 75 psi. Additional drill stem tests of the Arbuckle zone indicated some 50 ft of saturated section. Shows of oil were also recorded in this well in the Simpson, the Viola, and the Mississippian. The drill stem test yield from the Simpson in the interval 5882-5890 was an estimated flow of 60 bbl of oil an hour. In Cleveland County, the Continental Oil Company No. 1 Cook, producing from the Wilcox through perforations 7181-7182 ft, has been tested to flow 240 bbl of oil per day through a ¼-in. choke.

Also in Cleveland County British-American's No. 1 Price indicated a good well from the Bartlesville sand. Two hundred feet of 40-deg oil and 100 ft of heavy oil and gas cut mud were recovered through drill stem test from 8069-8092 ft.

★ Phillips Petroleum Company is completing a Springer sand discovery well in the Southeast Bradley area of Grady County, Oklahoma. The No. 1 Lack, which flowed 208 bbl of 43.9 gravity oil per day through a small choke from the lower portion of an 80-ft pay section topped at 9348 ft. The new discovery is six miles from the nearest Springer sand production.



TENIXTEPEC No. 1, test well successfully proved contention of Mexican oil engineers that "Faja de Oro" extended further shouthward. Wells No. 2 and 3 confirmed the hypothesis, and Ezequiel Ordoñez field is being groomed to become one of the major oil producers in Mexico.



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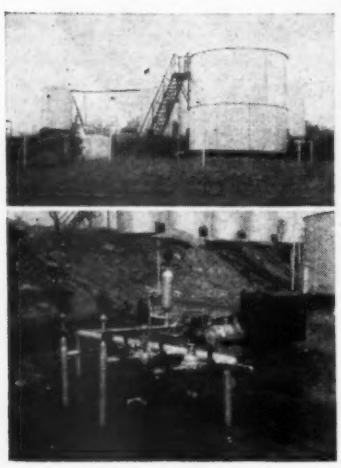

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PETROLEUM ENGINEERS
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WICHITA FALLS, TEXAS

EXPLORATION ACTIVITIES

YEMEN

★ Announcements of Germany's entry into the Middle East Oil search has been made. According to reports, a Hamburg firm has entered into an exploration and exploitation with the Imam of Yemen. The concession is to cover the entire 75,000 sq miles of the Arabian kingdom and grants German firm a monopoly on developments.

NORTH BORNEO

★ Drilling is to be commenced in North Borneo on a site adjoining the British-protected State of Brunei, where the Seria Oilfield, largest single oil field in the British Commonwealth, is producing 35,000,000 bbl annually.

Concession is held by Shell and covers about 1000 sq miles in 2 areas. At one of these, the Dent Peninsula on the East Coast, a technical party is carrying out a gravity survey. On the Klias Peninsula in the West, where wells have been drilled in the past without encountering oil in commercial quantities, it is planned to start a 7000 ft test.

MISSISSIPPI

★ The American Liberty Oil Company in northeastern Pearl River County is completing what appears to be the first oil production in the area which has previously yielded gas and gas condensate. In their No. 1 Hatten, approximately 1½ miles northwest of the Pistol Ridge field, they are testing the Eutaw sand, well known producing horizon of the state. Flowing on a 8/64-in. choke from gas perforations from 7416-21, the well was producing an estimated 100 bbl per day. Tubing pressure was 850 psi and reported gas/oil ratio was 500-1. This apparently successful test was originally drilled to the lower Tuscaloosa and plugged back for its present completion when no commercial shows developed in the lower zones.

TEXAS

★ Highlighted by Ellenburger discoveries, Texas wildcatters reported a reasonably successful month. Andrews County was in the lead in the big lime exploration with Anderson-Pritchard's Cowden, 13 miles southwest of Andrews. Completed from 48 ft of open hole with a total depth of 12,343 ft, the initial gage was 569 bbl a day through a 12/64-in. choke. Ellenburger was topped in this well at 12,296. Magnolia's Fasken No. 2, a long southeast extension to the recently completed Devonian and Ellenberger Midland Farms discoveries, has been successfully tested through at least 50 ft of Ellenberger pay. Reports of four tests of the zone are given below.

12,593-612 recovered 2100 ft of oil in 2 hours
12,612-627 flowed 27½ bbl of oil in 1 hour and 15 min
12,627-638 flowed 40 bbl of oil in 2 hours
12,638-648 recovered 240 ft of oil.

Operators are running liner for the completion attempt.

★ Cities Service et al No. 1 Payton, gas-condensate discovery in Pecos County, has been tested with good results from the Devonian. Drill stem gage from the interval 9815-65 was 3,790,000 cu ft a day with a gas condensate ratio of 54,000 to 1. The discovery well is situated approximately three miles southwest of Grandfalls.

★ East Texas has a new field indicated in Camp County near Newsome. The No. 1 H. G. Hatley was drill stem tested from the interval 8178-94, recovering 1900 ft of fluid with no water reported. This zone is known as the Pittsburg sand. The well had previously indicated as a Sub-Clarksville possibility through the stem recovery of 290 ft of 16 deg oil with 50 ft of oil cut mud on test of the interval 3854-57.

LOUISIANA

★ The California Company has announced the completion of a new discovery well in Lafourch Parish. The joint operation with the Superior Oil Company is the No. 1 Cloverly Corporation in the Cutoff area. Tested on a 9/64-in. choke, the well produced 308 bbl of 33.1 deg oil per day.

★ In Cameron Parish, north of the Big Lake area, Kerr-McGee Oil Industries has completed a new discovery well at their No. 1 LeBlue. Tested on an 8/64-in. choke, the well flowed at a rate of 348 bbl per day with a gas-oil ratio of 700 to 1. Production was through casing perforations in the interval 10,334 to 10,346 ft. An earlier drill stem test of a lower sand had indicated a gas condensate producer from 13,260 to 13,280 ft.

FLORIDA

★ Completion work is under way in the apparently successful deep joint venture 40 miles west of Miami. Operated by the Gulf Oil Corporation, the wildcat has had successful drill stem test from the Sunnifield formation. Five feet of saturated Dolomite yielded 2185 ft of clean oil and 365 ft of water with a strong initial flow of formation gas on a 12-hour test. Gravity of the oil was reported as 25 deg. Interval tested was 11,318-23 ft. The well was drilled deeper after test to 11,536 ft with additional shows below the tested interval being reported. This discovery is some 50 miles northwest of Humble's Sunniland field. The Humble field was discovered in 1943 and development substantially completed by 1950. No other production has been discovered in Florida since then.

KANSAS

★ The Texas Company has discovered an apparently excellent Simpson pay in eastern Kingman County. The No. 1 Graber showed gas to the surface in 10 min and flowed oil in one hour on a drill stem test in the Dolomite from 4460-4475 ft. Similar results were obtained in a second test from 4474-4482, although in this second test oil reached the surface 12 min after the tool was opened. The third test from 4482-4493 ft proved at least 33 ft of saturation by surfacing gas in 8 min and oil in 40 min.

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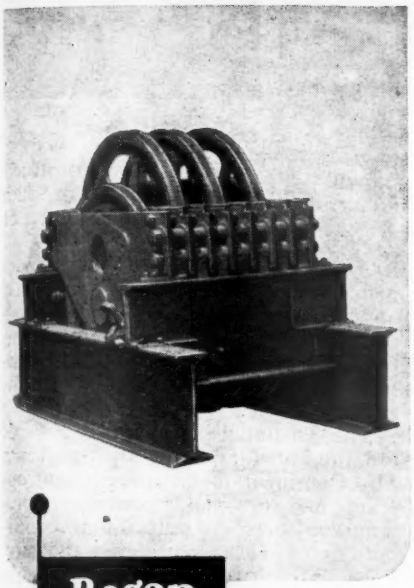

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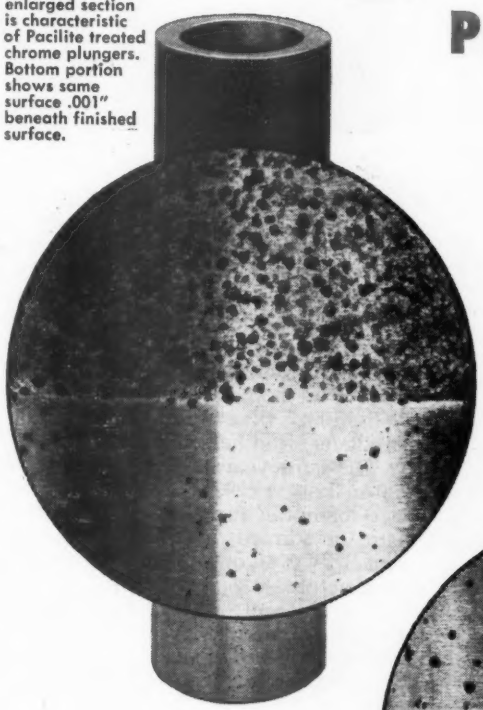
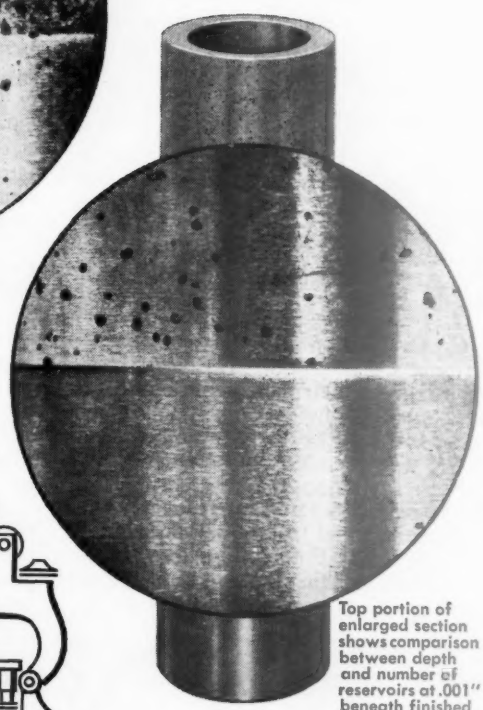
The number of surface reservoirs on top portion of enlarged section is characteristic of Pacilite treated chrome plungers. Bottom portion shows same surface .001" beneath finished surface.





Top portion of enlarged section shows comparison between depth and number of reservoirs at .001" beneath finished surface and .005" where controlled etching has eliminated reservoirs.

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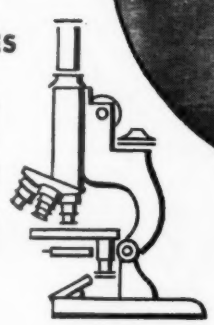
that actually soak up lubricants!



Pacific Pacilite process is a method of control etching a multitude of minute surface reservoirs to provide maximum retention of lubricants after the chrome plated plunger is ground to desired size. Result is much longer plunger life and virtual elimination of sticking and galling. Pacilite treatment also relieves high tensil plating stress and reduces possibility of cracking or shearing under heavy shock loads. For complete details write for Technical Bulletin No. 201.

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RUNNING TOUR WITH MEN IN THE INDUSTRY

Lewis McGuire has been promoted from assistant superintendent to superintendent of Continental Oil Company's East Kansas production district. McGuire succeeds **J. P. Neel,** who has retired. A native of Fort Gibson, Oklahoma, McGuire attended Chillicothe, Missouri, Business College and joined Conoco in 1936.

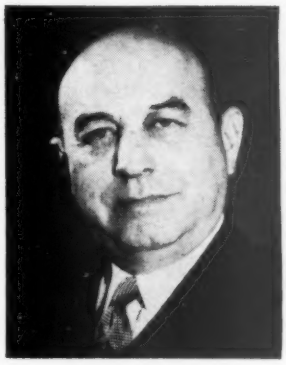
Vincent W. Vandiver, exploration geologist for the Western division of Seaboard Oil Company of Delaware, is being transferred to Dallas, Texas, according to an announcement by N. A. Rousselot, vice president and manager of the Western division. Joining Seaboard in 1939, Vandiver has had numerous assignments in California and has conducted initial investigations in the Rocky Mountain region. His new duties will be as assistant to R. A. Stehr, vice president and manager of exploration for Seaboard, with offices in the Continental Building, Dallas 1, Texas.

Prior to coming to California, and after graduation from the University of Missouri, Vandiver was employed by Standard Oil Company of New Jersey and subsidiary companies.

Harry L. Berry has been named landman-geologist by Francis Oil and Gas, Inc., and H. G. Kaiser. A graduate of the University of Oklahoma, Berry was formerly employed by Sinclair, Foundation Oil, and Manshan Oil Company.

C. C. Forbes, president of Noble Drilling Corporation, since 1948, has been named chairman of the board of directors of the organization. New president will be **P. M. Johns, Jr.,** Tulsa, vice president and treasurer.

Forbes will continue as chairman of the board of directors of Samedan Oil Corporation and trustee of the Samuel Roberts Noble Foundation, Inc. Johns is a gradute of the University of Oklahoma, joining the Noble firm in 1933.



H. W. Bass

A. G. Carter

H. H. Baker

Harry W. Bass, Dallas, Texas, drilling contractor and independent oil and gas producer, was elected president of the Texas Mid-Continent Oil and Gas Association, at the second-day session of the association's 34th annual meeting. Bass became the 14th president of the state's oldest and largest organization of oil men. He succeeds Robert F. Windfohr, Fort Worth independent producer, who held the post two years.

The same year he began hammering cable tools, 1919, Bass joined the firm of Champlin and Winkler. Six years later he formed the firm of Champlin and Bass as an oil operator and drilling contractor.

The present Harry Bass Drilling Company operates 18 rotary rigs on locations stretching from the Rio Grande to Peace River, Alberta. He formed Can-Tex Drilling Company, Ltd., in 1941 for exploration in Alberta. He originated the first A-frame portable derrick in 1928. It is still in use.

Bass formed the Trinity Gas Corporation in 1939. He was one of the first to build a cycling plant in Texas.

Bass is president of the Wilcox Trend Gathering System, Inc., a 150 million cubic-feet-per-day pipe line which gathers gas from the Wilcox trend of South Texas. He also heads Goliad Corporation, which is now constructing two natural gasoline plants in South Texas to process 300,000,000 cu ft of gas per day.

Amon G. Carter, Fort Worth, independent oil producer and publisher, and **Hines H. Baker,** Houston, president, Humble Oil and Refining Company, received the Texas Mid-Continent Oil and Gas Association's Distinguished Service Awards for 1953.

The Distinguished Service Awards are presented annually by the Texas Mid-Continent to an independent operator and to a major company representative for their outstanding contributions to Texas petroleum industry.

In addition to his activities as publisher of the Fort Worth Star-Telegram, Carter has been active in the oil business for many years. He supported the first proration move in Texas and was one of the leaders in the fight to obtain recognition for West Texas in the state's proration picture, urging the across-the-board policy now employed by the Railroad Commission.

President of Humble since 1948, Baker is a legal scholar and the author of several papers on conservation, depletion allowance, and the tidelands question, which are frequently-cited reference works.

P. L. Lyons

J. H. Wilson

R. F. Bennett

R. B. Ross

R. Brewer

H. M. Thralls

Paul L. Lyons of Tulsa, exploration manager for Anchor Petroleum Company, and **John H. Wilson** of Fort Worth, exploration consultant and vice president of Piper Petroleum Company and Woodson Oil Company, are presidential nominees of the Society of Exploration Geophysicists for 1954-55.

Nominated for vice president are **Roy F. Bennett** of Houston, chief geophysicist for the Sohio Petroleum Company and **Ralph B. Ross** of Pittsburgh, Pennsylvania, supervisor of geophysical and structural geology of the geology division of the Gulf Research and Development Company.

Candidates for secretary and treasurer are **Richard Brewer** of Shreveport, district seismic supervisor for Atlantic Refining Company, and **Hugh M. Thralls** of Tulsa, vice president and director of Seismograph Service Corporation. He was with the Shell Oil Company from 1934 to 1936.

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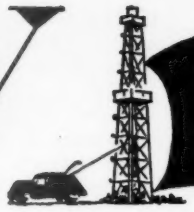

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RUNNING TOUR

Arthur P. Allison, district geologist for Sun Oil Company, has been retired after 23 years of service. Allison has been in Shreveport, Louisiana, since November, 1947, when he opened a district geological office for Sun. Joining Sun as a field geologist Allison was made a field clerk in the Henderson area, East Texas in 1931 and a year later went into the land department as a scout at Livingston, Texas.

Allison was moved to Houston in 1934 as a sub-surface geologist, was promoted to district geologist in 1935 and stayed there until his transfer to Shreveport.

Sun's office will be given a local status and be under the supervision of **D. C. Harrell,** district geologist of Jackson, Mississippi. **Frank Craver** is in charge of local activities now in Shreveport.

Thomas P. Pike, California industrialist and oil well drilling contractor, has been appointed deputy director of the Defense Department's newly created agency to coordinate supply and logistics for the Armed Services. The appointment was announced by Charles S. Thomas, Assistant Defense Secretary. The new Defense Department agency has been set up to streamline Army, Navy, and Air Force procurement and supply procedures and to trim expenditure when possible.

Richard R. Von Hagen has been elected president of Lloyd Corporation, Ltd., succeeding the late Ralph B. Lloyd. Also announced is election of **M. J. Dees** of Ventura, California, to the office of vice president. Lloyd Corporation headquarters are at 9441 Olympic Boulevard, Beverly Hills.

Jerald L. Stauss, Tulsa, of Falcon Seaboard Drilling Company, has been named vice president in charge of the company's operations in the Rocky Mountain area.

Ted Law, president of Falcon, announced that Stauss would be in complete charge of the Rocky Mountain operations in addition to his present duties as vice president of the Mid-Continent area and treasurer.

Stauss, who has been with Falcon Seaboard since it was organized in 1935, has worked in all capacities in the organization. He joined the drilling company after completing his business administration college course.

Ford L. Johnson, manager of Sun Oil Company's physical laboratory at Newtown Square, Pennsylvania, has been appointed acting director of the research and development activities for the production department.

Johnson will have charge of directing and coordinating the activities carried on in the various laboratories and field offices of the production department.

Preston E. Chaney, manager of the production laboratory at Beaumont, Texas, will serve as assistant director in charge of exploitation. He will maintain his headquarters at Beaumont.

C. N. White has been appointed administrative assistant to Johnson, and will be situated at Newtown Square.

C. S. Yust, toolpusher, Lovell Lake district, Gulf Coast division, Humble Oil and Refining Company, recently was promoted to assistant district superintendent of the Winters district, North Texas division.

C. L. Sparkman, toolpusher, Potash district, Louisiana division, was transferred to the Athens district, East Texas division, as toolpusher.

Philip Mantor, who has been acting assistant chief petroleum engineer in the petroleum engineering division, Houston, for the last two months, has returned to the Southwest Texas division office as assistant division petroleum engineer.

C. M. Carothers, returned to his regular assignment at Stratton as district supervising petroleum engineer after relieving Mantor in the Southwest Texas division office as assistant division petroleum engineer.

W. W. Kalteyer, district petroleum engineer, Imogene district, Southwest Texas division, resigned September 1 to go into business for himself.

J. H. Cuthrell, returned to his regular assignment as regional employee relations manager of the Louisiana division after three months in the Houston office as acting assistant manager, employee relations department.

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Actual photograph of a typical Otter cargo load. The Otter's cabin measures 16' x 4'6" x 4'6", or 345 cubic feet.

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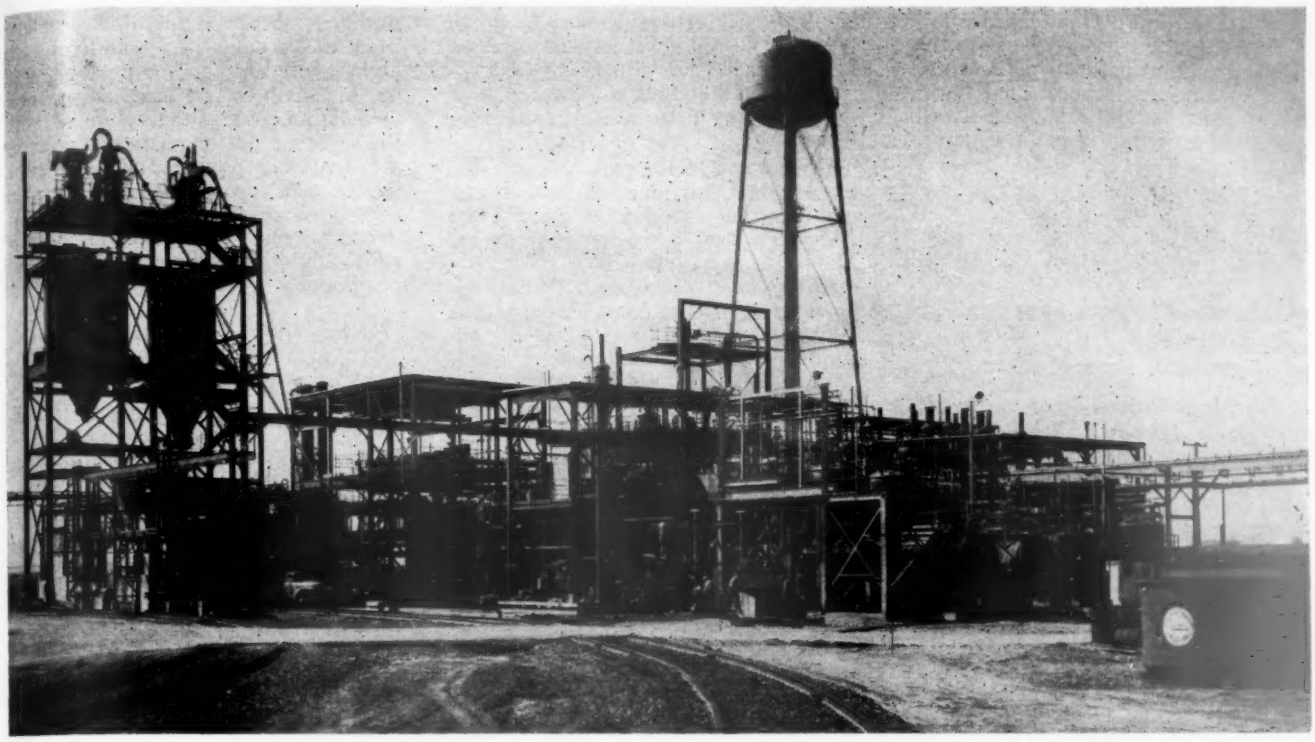


MONSANTO CHEMICAL COMPANY'S Avon, California, plant which began operations in October, 1953.

Synthesis of Petrochemicals—4

Phenol, Acetone From Cumene

Rapid growth of phenol demand gives bright outlook for synthetic product and new process

ARCH L. FOSTER*

PHENOL (carbolic acid) is one of the oldest of the "modern" organic chemicals. Derived from natural sources in its earlier history, it has advanced to synthetic routines, including the use of chlorinated and sulfonated intermediates in which most of the phenol of recent manufacture consumes great quantities of chlorine and sulfuric acid, which agents form byproducts of nominal and uncertain value.

Acetone is one of the oldest commercial products both as a chemical intermediate and a general industrial solvent. Its original sources, in quantity, was by concentration from the raw liquor from destructive distillation of wood. More recently it was made from hydrocarbons by oxidation or by fermentation of corn, molasses, etc., or more generally by oxidation of i-propyl alcohol.

Phenol is one of the most important of all organic chemicals, as solvent, chemical intermediate, disinfectant, etc. In 1952 total U. S. production of phenol was nearly 364,000,000 lb of which less than 25,000,000 lb was natural phenol, according to estimates, the remainder being synthetic. In the same year nearly 440,000,000 lb of acetone was produced in this country, with a correspondingly small proportion of natural product.

As of now this country has eleven phenol plants operating or building. Of these units four are sulfonation processes, three employ chlorination, one is a large-scale pilot plant for coal hydrogenation — with phenol as by-product — and three are building to use the so-called cumene process. One cumene process unit began operations this spring (May, 1953), in Montreal, Canada. (Refining and Petrochemical Edition, September, 1953, p. C-27.)

Current Synthetic Phenol Processes

Three major processes for phenol synthesis are now extant in this country; one uses chlorination of aromatics such as benzene—for primary phenol, C_6H_5-OH — to monochlorobenzene, followed by hydrolysis with a water solution of an alkali to yield phenol direct. The same idea is employed by reacting benzene with sulfuric acid to give benzenesulfonic acid, C_6H_5—SO_3H, which is hydrolyzed in similar fashion. Both these processes yield chlorine and sulfonic acid derivatives of 'limited' application and market value, and thus do not give satisfactory reduction of the cost of the main product.

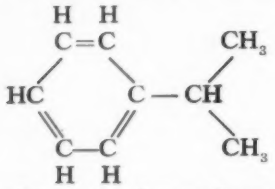
More recently two organizations have been carrying out intensive research on production of phenols via the hydroperoxides of aromatic derivatives route, such as cumene. The Distillers Company, Ltd. of England, prosecuted research on this method, as early as the late 1930's. Working independently Hercules Powder and Allied Chemical and Dye have carried the work further, and Hercules has obtained the American rights, patent, etc., of Distillers covering the basic opera-

*Editor, Refining and Petrochemical

EXCLUSIVE

tions worked out by that company.

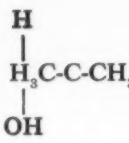
Basically, the synthesis is carried out in three main steps; cumene is synthesized by the process perfected during World War II via Friedel & Crafts alkylation procedure, has the structure,



(Cumene or i-propylbenzene).

By oxidation with air cumene hydroperoxide is formed. This in turn is 'cleaved' practically quantitatively into phenol, C_6H_5-OH, the hydroxyl, -OH going on the benzene nucleus in place of the i-propyl radical, and acetone, H_3C-C-CH_3. Nieuwenhuis* states that

i-propyl alcohol,



is the present main source of acetone, by oxidation of the hydrogen from the (OH) hydroxyl group.

Alkylation of benzene with i-propyl chloride to form cumene follows the well known Friedel and Crafts reaction, with $AlCl_3$ as catalyst. Beginning with this product, used in large quantities in the last war for a constituent of aviation fuel, as relatively impure alkylate phenol production calls for high purity cumene. Air is introduced into a reactor with cumene at about 130 C (266 F), and the hydroperoxide is formed quantitatively, either in an inert solvent or in an emulsion of cumene and water using sodium-stearate, -lauryl stearate or -ricinoleate as emulsifying agent. Theoretically the reaction should go to 100 per cent completion for optimum results, but in practice it is found advantageous to arrest reaction when about one-third to one-half of the cumene has reacted to the hydroperoxide.

This yield of hydroperoxide is segregated; in the presence of a catalyst such as sulfuric, p-toluene sulfonic, phosphoric or acetic acids, and at elevated pressures, the hydroperoxide is broken into two products acetone and phenol. The crude reaction stream includes some 14 per cent phenol, 8.4 per cent acetone, 75.4 per cent cumene, 1.4 per cent methylstyrene and 0.8 per cent acetophenone.* Thus the yield of acetone is about .06 of that of phenol.

The two byproducts, acetophenone and alpha-methylstyrene, the latter containing a double bond in the side-chain, affect somewhat the economics of the process as given later herein.

*Two important recent articles from which most of the data given herein were taken are: Cumene Process, Etc., H. K. Nieuwenhuis, Chemical Week, May 2, 1953, page 30. Phenols From Hydrocarbon, Etc., H. I. Enos Jr. & J. R. Nixon Jr.—American Chemical Society, Chicago, Ill., Sept. 6-11, 1953.

Typical production shows 1 lb of phenol and 0.6 lb acetone for each 1.5 lb of cumene, plus 0.1 lb methylstyrene and 0.06 lb acetophenone, high results in any large-scale organic synthesis.

Phenol and acetone are concentrated by suitable fractionation procedures, and thus separated from each other and from the two main byproducts. The unreacted cumene is recycled. The methylstyrene is hydrogenated by well-known reactions to cumene and is thus recycled, or may be sold "as is" depending on price conditions.

Fortunately, this process can be employed not only with benzene (or cumene) as starting material but with toulene, xylenes, and similar homologues. Also, by the proper choice of intermediate aromatics several compounds may be produced, such as para- and mixed cresols, naphthols, hydroquinone and resorcinol. Alcohols, ketones, and diperoxides may be formed also by this hydroperoxide-and-cleavage reaction. p-Cresol is being made by Hercules in Mississippi; also, the same company is making resorcinol, i-propylphenol, and hydroquinone, in Georgia.

Possibly the most far-reaching and important principle in this whole synthesis is that thereby a huge number of chemically and industrially important products can be made economically. High yields of alcohols are made by reducing agents. Ferrous sulfate, Fe SO_4, gives largely ketones. Interestingly enough, these hydroperoxides are strong catalysts for the polymerization of olefins. This reaction gave reason enough for the production of large quantites of cumene and other homologous hydroperoxides as catalysts in the "cold rubber' process, announced after the end of World War II.

Plant Cost for Phenol-Acetone Synthesis

The latest estimate for the cost of a phenol-acetone plant,* for 50,000,000 lb of phenol, and 30,000,000 lb of acetone annually is about $10,000,000; this figure does not include site costs. Additional costs include operating labor, repair labor, maintenance materials and utilities, and 10-year depreciation charges, amounts to about 3.1¢ per lb of the co-products, acetone and phenol. The raw materials cost, here, is estimated at about 5¢ per lb of the final co-products. The value of alpha-methylstyrene may range from the market value of cumene, less hydrogenation cost to form the latter, to the existing market price of 20-25 cents per pound. As of the summer of 1953 the market price of acetophenone was about 75 cents per pound. Two factors affect its influence on the net cost of phenol-acetone synthesis—with greater quantities of the phenone available that price may hold, likely not; as counteractant, with this material at lower price, many other uses for it may and probably will develop. Economics is the be-all and end-all of industrial chemical development. In the costs outlined above, a nominal credited price of 10 cents per pound for both alpha-methylstyrene and acetophenone are assumed, for purposes of practical calculation. Interestingly enough, with the existing acetone market price of 8.5 cents per pound, phenol costs by the cumene process 7.2 to 8.3 cents per pound, depending on yield and by-product value. Added to this must be general overhead that runs 3.5-4 cents per pound.

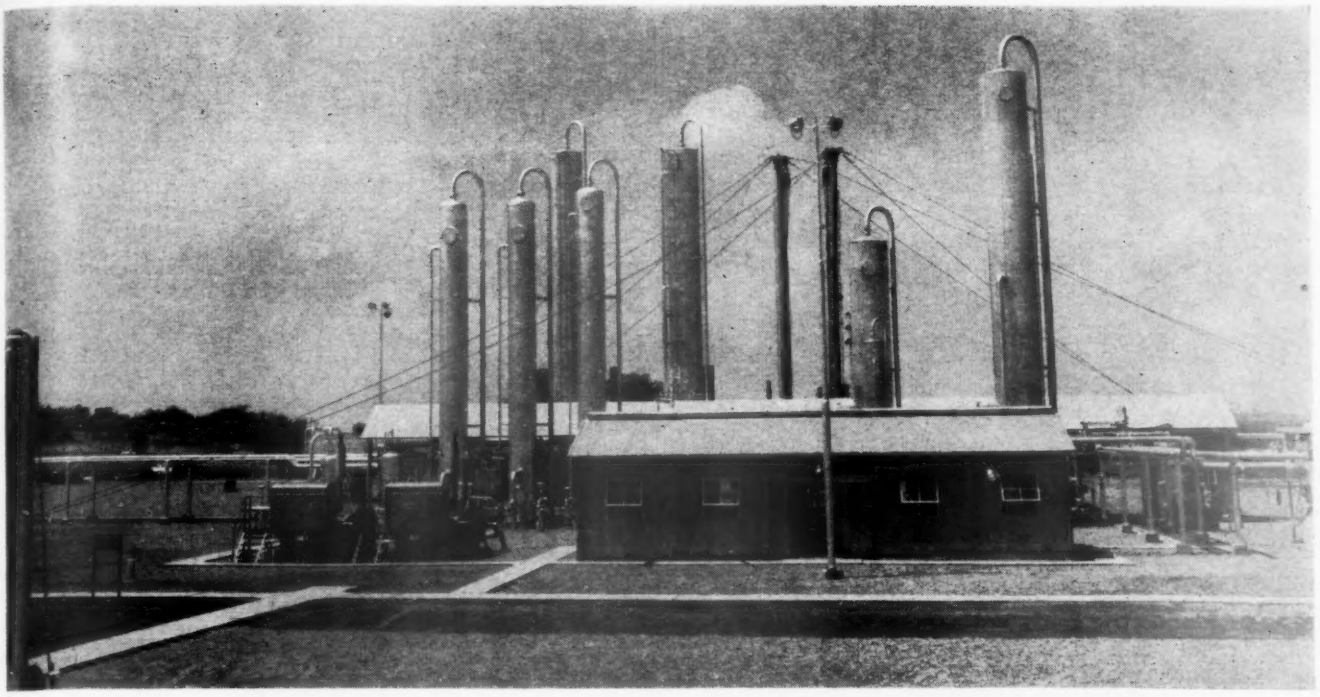
Factors Influencing Phenol Costs

Another estimate of cost* considers the fact that phenol-acetone production this year, considering all conditions is on a sound economic basis. As of the first of 1953, the following plants* were operating or building:

Company and location	Capacity, estimated operating	Million bbl building	Process
Barrett Division, Allied Chemical and Dye,			
Frankford, Pa.	20	—	Sulfonation
Frankford, Pa.	—	30	Cumene
Dow Chemical			
Midland, Mich.	150	40	Chlorination
Durez			
Tonawanda, N. Y.	35	30	Chlorination
Hercules			
Paulsboro, N. J.	—	15	Cumene
Monsanto			
St. Louis, Mo.	70	—	Sulfonation
Avon, Calif.	—	30	Sulfonation
Oronite			
Richmond, Calif.	—	35	Cumene
Reichold			
Tuscaloosa, Ala.	48	12	Sulfonation
Carbide and Carbon			
Marietta, Ohio	60	—	Chlorination
Institute, W. Va.	—	3	Coal Hydrog.
Total capacity	383	195	

According to informed sources* cumene process may be expected to be producing 50-65,000,000 lb of acetone per year by 1955. If acetone is to be considered a byproduct, the return from which is to be deducted from the overall cost of phenol, under existing conditions each pound of acetone will reduce the cost of phenol by 5 cents; for each one cent drop in acetone price this process loses 0.6 cents per pound of its cost advantage over the older processes. Estimates indicate that plant cost will average about $400 per ton of phenol per year. The Durez unit is said to cost about $426 per ton of phenol per year, using the chlorination process. Coal hydrogenation has not been carried on far enough to make safe estimates, it is believed. The Fischer-Tropsch hydrocarbon synthesis as installed at Brownsville (Carthage Hydrocol) can produce about 7 lb of acetone per 100 lb of butane converted to oxidation products; or about 10,000,000 lb per year. Output there has not come up to design values, up to now. Celenese uses air oxidation on natural gas in two Texas plants, Pampa and Bishop, on which definite capacity or production figures are not available. Cities Service has made oxygenated hydrocarbon products for many years at Tallant, Oklahoma.

Altogether, the outlook for phenol and its manufacturers is bright and indicates increasing demand for this important chemical. * * *



MAIN part of Ft. Chadbourne plant. Pump house in foreground; in background two absorbers, reabsorber, debutanizer, depropanizer, primary still, and secondary still.

Air Cooling Improves Economy of New Gasoline Plant Operation

ARCH L. FOSTER*

SITUATED in the more easterly stretches of the "Great Texas Thirst" the Fort Chadbourne gasoline plant of Lone Star Producing Company handles raw field gas in an area where formerly the jack rabbit, cow poke, longhorn steer, and the wild Comanche ranged far and wide. Only vestiges remain of the old Fort where soldiers were stationed to hold in check the cattle rustlers, white and red. Crumbling 'dobe buildings on some of the old ranches activate imagination of the conditions that obtained here a century ago. Now dull civilization tends to replace the picturesque with the practical.

Designed for a throughput of up to 30,000,000 cu ft of raw separator gas per day, it is at present processing some 20-21,000,000 ft. From this throughput the plant at present is recovering a typical yield of 48,000-50,000 gal of natural gasoline, and butanes, per day, of which 18,000-20,000 gal is natural gasoline, and 30,000-34,000 gal is butanes for LPGas consumption.

Air-Cooling Predominates

Forced draft air condenser-cooler equipment is used largely in the design of the plant, situated in an area where good process water is at a premium, but plenty of "atmospheric air" is available, far from centers of industrial pollution and its attendant problems.

Primary equipment employed includes two high-pressure absorber towers and one reabsorber unit. A primary and a secondary still tower, along with a depropanizer and a debutanizer tower complete the main battery. For gas compression three 1320 hp, 12-cylinder, 2-stage Angle compressors handle the incoming field gas, while two 1100-hp, 10-cylinder, 2-stage units inject the residue gas back into the reservoir. The primary still condensers use atmospheric cooling, and the secondary still condensers are air cooled units. Air cooling is used for debutanizer reflux condensers, and the depropanizer overhead is handled in atmospheric condenser-coolers. Air coolers are used also to cool the compressor engine jacket waters and the engine lubricating oils.

One atmospheric cooling tower is employed for interstage gas cooling on the compressors. Another atmospheric tower is employed to cool process streams (either directly or as adjunct to air coolers.) For "home" produced power two 375 kw generators are driven by 540 hp gas engines. Jacket water and lubricating oil for these engines are cooled by air coolers; one set is in operation, one standby in this power unit.

Three package-type water tube steam boilers, rated at 15,000 lb of steam per hour each, are fired with residue gas and supply all steam needs for the plant.

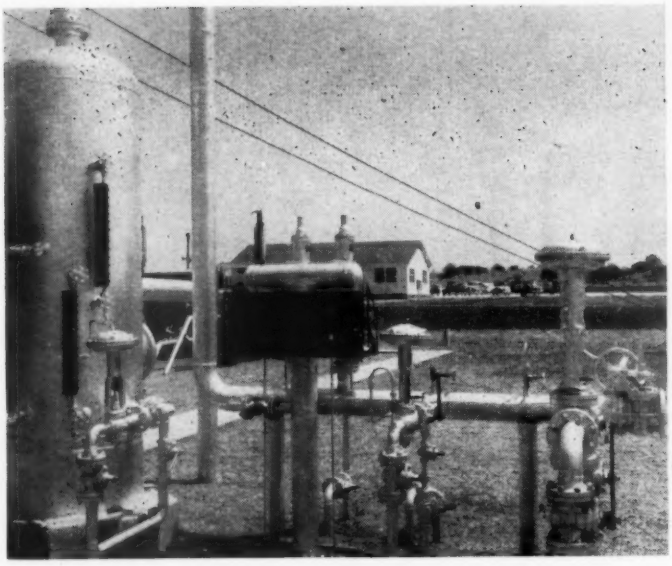
Water for the plant is obtained via pump and pipe line from Oak Creek Lake, water source for the city of Sweetwater, 40 miles away. The pipe line is about six miles long, and the water is discharged into a settling tank, treated with aluminum sulfate as flocculant, then with chemicals to purify it for plant use both in cooling towers and boilers.

The plant has installed an outside (roadside) loading dock for truck loading all products. Also, a railroad loading rack is installed on the Panhandle & Santa Fe railroad, seven miles away, for loading tank cars.

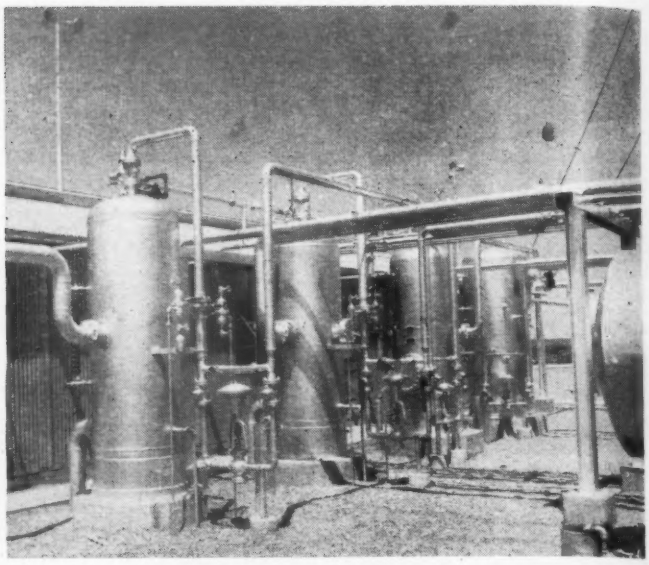
A deethanizer tower, delivery of which was delayed, is going in to permit the manufacture of commercial pro-

*Editor, Refining and Petrochemical Edition.

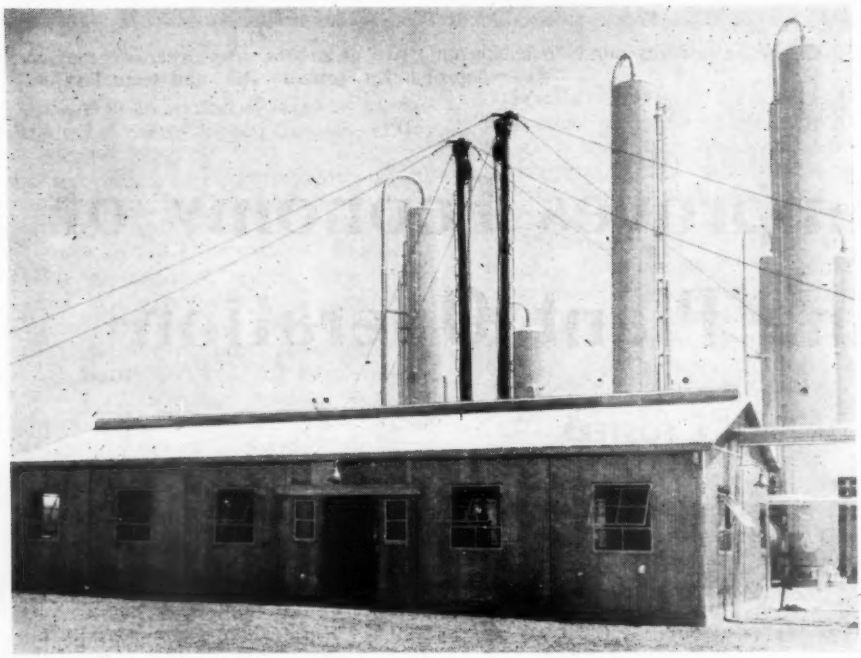
EXCLUSIVE



REABSORBER residue gas scrubber, left, with office building in background.



FRACTIONATOR reflux accumulators in front, fractionation pump building in background.

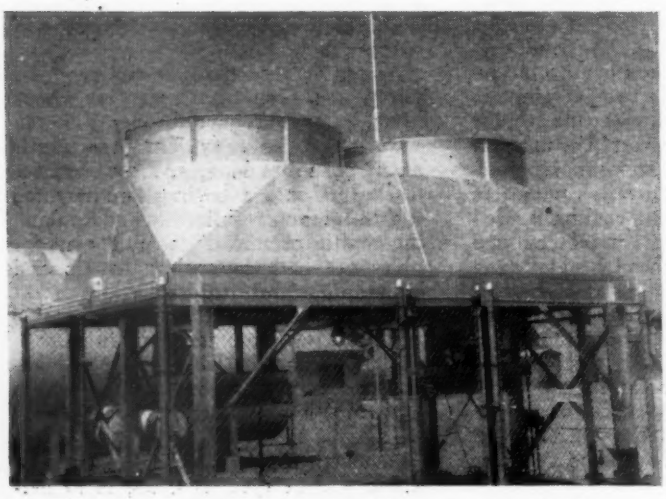


pane as another LPGas product and the new setup should be in operation before October 1, 1953. Ginpoles for hoisting the new tower into place are seen in some of the accompanying photos of the plant.

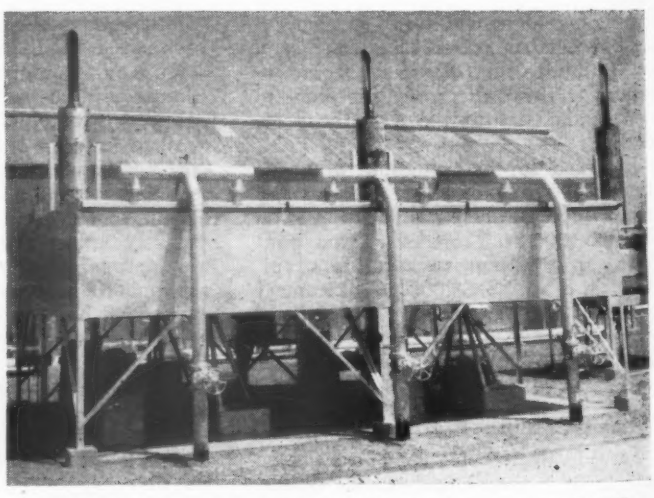
Flow of Gas and Product Streams

Raw field gas is received at the plant at 50-60 psig, passes through the inlet scrubber and thence through two stages of compression it is boosted to 500 psig. The gas then goes to the absorbers to pass in countercurrent flow to the lean absorption oil. The residue gas from the absorbers is compressed to 1150 psig, cooled and sent to the fourth stage where it is compressed to 2750 psig, at which pressure it goes back to the field

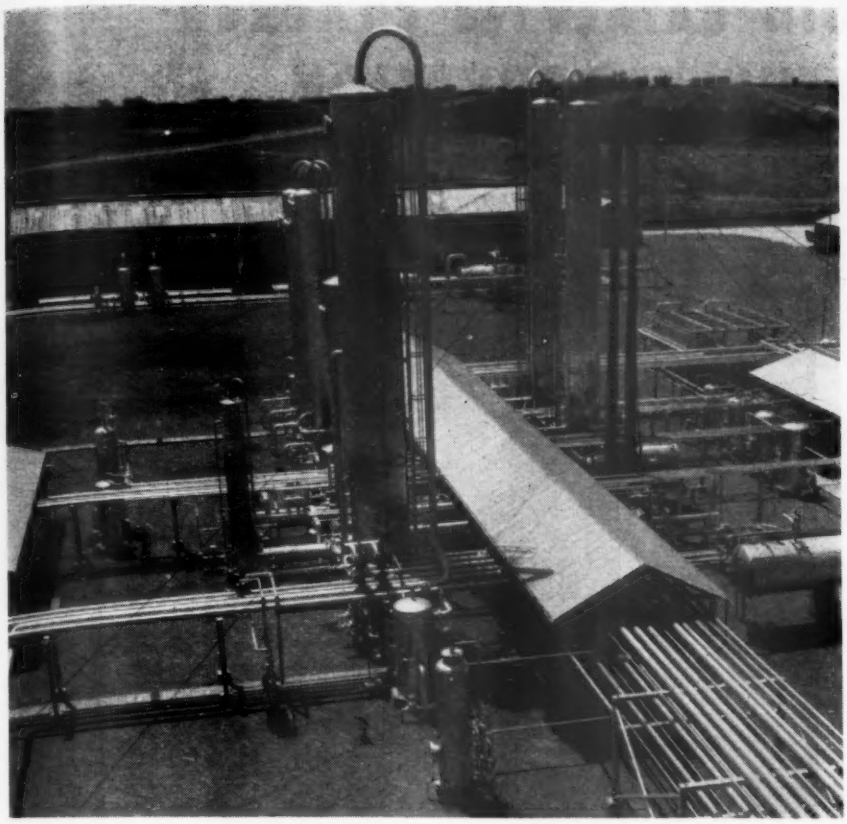
FRACTIONATION pump building, left photo; background, left to right, secondary and primary still, depropanizer, debutanizer, with absorbers behind it.



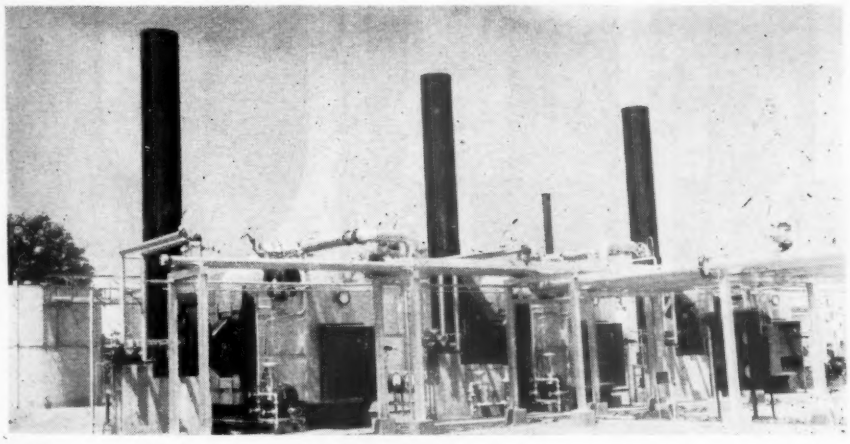
JACKET water and lube oil cooler for compressor engines.



ENGINE jacket water coolers, in front of compressor building.



DISTILLATION unit, and fractionator, left, and right foreground with compressor building in background.



THREE steam boilers supply all power and process steam required.

and is injected into input wells to repressure the reservoir.

The rich oil from the absorbers is transferred to the primary still via the heat exchangers, and part of its load of light hydrocarbons is removed in this still. The partially stripped rich oil is preheated again and sent to the secondary still where the remaining hydrocarbons are taken out overhead. Stripped absorption oil then goes from the secondary still bottom to the shell side of the heat exchanger to preheat incoming oil to the primary still, then is cooled in atmospheric sections and sent to the lean oil surge tank.

Incidentally, the two high pressure absorbers are designed to operate at 500 psig, and the reabsorber at 175 psig. The primary still works at 160 psig and the secondary still at 80 psig. The depropanizer mentioned below operates at 250 psig and the debutanizer at 140 psig. The deethanizer now being installed will operate at 500 psig. About 100 gal of lean oil goes to the reabsorber per minute, and 200 gal per minute to the absorbers.

The primary still overhead vapors pass to atmospheric condensers and then to the raw make-tank. Secondary still overhead passes to air cooled units and to atmospheric coolers then to a rundown accumulator from which it is pumped to the raw make-tank. All raw product, charge, reflux, and rundown pumps are of the steam-driven reciprocating type.

TABLE 1. Fort Chadbourne inlet gas composition.

	Mo. per cent	G.P.M.
Methane	54.92	....
Ethane	18.21	....
Propane	20.44	5.60
Iso-butane	1.43	0.47
N-butane	3.50	1.10
Iso-pentane	0.41	0.15
N-pentane	0.45	0.16
Heptanes plus	0.64	0.29
	100.00%	7.77

G.P.M. — (26° gasoline) 0.90
Separator pressure 70-psig.

TABLE 2. Typical distillation data on lean oil, butanes, and natural gasoline streams at Fort Chadbourne plant.

Natural gasoline	
Vapor pressure, lb Reid	13.8
API gravity	84.0
Initial boiling point	88 F
End point	238 F
Recovery	95–6 per cent
Butanes	
Vapor pressure, lb Reid	80
Initial boiling point	minus 6 F
End point	plus 27 F
Lean oil (from system)	
Initial boiling point	210 F
5 per cent	430
10 per cent	470
20 per cent	512
30 per cent	520
40 per cent	536
50 per cent	545
60 per cent	551
70 per cent	556
80 per cent	560
90 per cent	565
E.P.	604 F
Recovery	96%
Residue	2.5%
Loss	1.5%

The raw gasoline from the make-tank is picked up by pumps and is presently sent to the depropanizer tower from which propane and lighter go overhead and back to the reabsorber tower where it meets lean oil; the stripped overhead from this reabsorber goes to the second stage of the field compressors. Bottoms from the reabsorber—rich oil—goes through heat exchangers to join the rich oil from the high pressure absobers and on through the system as described above.

Bottoms from the depropanizer are sent via preheat exchangers to the debutanizer, butanes—LPGas—are taken overhead and without further treatment sent to storage. Debutanizer bottoms is the natural gasoline finished product, and for 1953 summer output it cut to 14 lb Reid vapor pressure.

When the new deethanizer tower is in operation conditions will be changed to recover the propane now lost to residue. Raw gasoline from make-tank will pass to this deethanizer tower and propane for LPGas purpose will be recovered to augment the total LPGas production. From Table 1 it is noted that the combined propane-butanes content of the raw gas is 25 mol per cent, or a total of 7.17 gal per 1000 cu ft of which butanes, now recovered, constitute only 1.50 gal per 1000 cu ft.

Table 2 shows typical composition—distillation, etc.—of natural gasoline. This gasoline is slightly sour and requires sweetening treatment to meet market specifications. The new deethanizer tower is expected to be in operation the latter part of 1953. * * *

XUM

SECOND UOP FLUID CATALYTIC CRACKER FOR BAY PETROLEUM CORPORATION . . . BUILT BY

PRO

XUM

CON

On stream July 16, this new UOP Fluid Catalytic Cracking unit at the Denver refinery of Bay Petroleum Corporation is another outstanding construction project successfully completed by Procon.

In addition to building this 3,500 barrel-per-stream day cracker, Procon also revamped polymerization and gas concentration facilities, modernizing existing equipment for increased crude capacity.

This is the second cat cracker built by Procon for Bay Petroleum, the first being at their Chalmette, La., refinery — an open indication of Bay's confidence in Procon's ability to handle the job efficiently and economically.

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Reliable Electric Power Essential to Processing*

Although standard in most respects, special applications minimize effect of system troubles

T. L. CAPPEL, JR.

A PETROLEUM refinery consists of a number of individual plants referred to as process units. Each of these units has a specific function, such as, crude oil distillation, catalytic cracking, lube oil treating, etc. All process units use electric power in their operations, and the individual requirements range from approximately 100 to 5000 KVA. The larger units, which constitute over 50 per cent of our total power requirements, present an average load in the range of 1500 to 3000 KVA. These larger units operate on a continuous basis, and, as a general rule, are shut down no more than once a year for maintenance (turnaround). Unplanned shutdowns of the units can be very costly.

Satisfactory operation of modern process units in the Baton Rouge refinery of the Esso Standard Oil Company depends upon the uninterrupted supply of electric power. We are faced, therefore, with the problem of designing an electrical system which supplies power with suitable reliability. An extensive study of various alternates by personnel of the Standard Oil Development Company and Baton Rouge refinery resulted in the selection of a secondary selective type of system with automatic transfer of loads. This was felt to be the most satisfactory system based on economics, flexibility, and simplicity. This presentation deals with the details of the design of the electrical system for typical modern process unit utilizing the secondary selective scheme.

Fig. 1 is a one-line diagram of the electrical facilities for such a process unit. For the purpose of discussion we shall consider the one-line diagram to consist of the four following parts: (1) Motor and motor control. (2) Turnaround and lighting circuits. (3) 2400 and 480-v switchgear and transformers. (4) Relaying scheme for automatic transfer of load in the switchgear.

Motors and Motor Control

The majority of the motors in a typical process unit are integral horsepower sizes with ratings up to approximately 600 hp. In most cases, motors rated 100 hp and above operate on the 2400-v system and the smaller ones on the 480-v system. Explosion-proof motors are used in the process area as a general rule. Some weatherproof squirrel cage induction motors in larger sizes are used outside the immediate process area.

Starting equipment for these motors is normally general purpose equipment located in a building in a suitable area. For 2300-v motors, metal-clad drawout switchgear is used. Motor control centers consisting of magnetic contactors and plastic case circuit breakers are used for 440 v. In some cases, it is desirable to use 440-v motors above 100 hp, and in these cases 480-v metal-clad drawout switchgear is provided for motor control.

The protective devices for 2300-v motors consist of thermal overcurrent induction time overcurrent, instantaneous overcurrent, and induction time undervoltage relays. The thermal overcurrent relays are provided on the basis of their ability to match the heating curve of the motors and allow the maximum utilization of these motors. The induction time relays are used to provide overcurrent protection in the range of locked rotor conditions. The instantaneous overcurrent relays are used to operate under fault conditions, and the induction time undervoltage device is used to protect the motor from prolonged undervoltage.

The importance of avoiding upsets in the operating process units by uncontrolled tripping of major motors has led to our system of using the thermal relays to sound an alarm. The operator of the unit can then take steps to remove the overload from the motor without causing an upset of the process. The other relays, however, trip the starter, but allow restarting if necessary. When the instantaneous relay trips the starter, it is presumed that a failure has occurred and a lockout device operates to prevent restarting.

Protective devices for 440-v motors consist of standard low voltage bimetallic thermal overload relays, plastic case circuit breakers, and time delay undervoltage relays. The operation of the units is similar to that for 2300-v motors, except that the alarm system for small overloads is not used since the loss of a smaller motor in general does not cause a major upset of the process operation. Another difference is that the circuit breaker trips on either locked rotor or fault conditions and, consequently, "locks out" the starter.

Turnaround and Lighting Circuits

Turnaround and lighting circuits usually feed 480-v welding receptacles, 120-v general purpose receptacles, 120-v lighting circuits, and 120-v instrument circuits. These circuits are combined into a unit of 480-v switchgear referred to as the turnaround center.

The 480-v welding receptacle circuits are more or less standard circuits fed by a circuit breaker in the turnaround center. The receptacles are grouped on each circuit in such a manner as to utilize the circuit breakers to maximum advantage.

A feature of the 120-v circuits is that distribution is made with 480-v feeders to various points throughout the unit. At these points dry type transformers are installed to provide 120-v power to a circuit breaker panelboard. This type of system gives substantial improvement in voltage regulation and control as compared to a system utilizing a large lighting transformer in a central location. As a general rule, these 480/120-v transformers range in size from 5 to 10 KVA and are provided with two taps below rated voltage.

General lighting circuits for outdoor areas consist of varying combinations of floodlights and 100-200-watt lighting fixtures and are grouped on one or more electrically operated 480-v circuit breakers in the turnaround center. This allows the use of a remote pushbutton station in the unit control house to control the general lighting.

The Author

Thornton Leon Cappel, Jr., has been a member of the mechanical engineering department at Esso's Baton Rouge, Louisiana, refinery since August of 1946. At present he is head of the department's Electrical Engineering group. He joined the refinery after service in World War II, attached to the Navy's electronics field service group.

Cappel attended Louisiana Polytechnic Institute, Ruston, and the college of Engineering at Louisiana State University, Baton Rouge. He continued his studies at Tulane University, New Orleans, under the Naval Reserve Program, receiving the degree of bachelor of engineering in electrical engineering in 1944.

*Presented before Baton Rouge Section, American Institute of Electrical Engineers, 1953, under the title "The Electrical Facilities for a Modern Petroleum Process Unit."

Other lighting circuits, such as those used for gage glass lighting, control house service, instruments, and 120-v convenience outlets, are fed from manually operated circuit breakers in the turnaround center.

Transformers and Switchgear

Size of the main transformers is normally determined by the voltage drop occurring during a transfer of load from one transformer to the other. The limitation at present is considered to be 15 to 20 per cent drop in voltage, with all motors being transferred assumed to be under standstill conditions. Occasionally size of the transformers is determined from load considerations, and in this case the firm capacity of a pair of transformers is considered to be the fan cooled rating of one of the units, which is approximately 125 per cent of the normal rating.

Some protection for the transformers is afforded by overcurrent relays in the switchgear, however, primary protection is obtained through the use of a gas pressure relay mounted on the transformer case. This is a device that operates on sudden changes of gas pressure in the transformer and supposedly is capable of determining failures of a smaller magnitude than any of the conventional relays.

The switchgear used is of the metal-clad drawout construction with air break circuit breakers. Air break circuit breakers are used on the basis of ease of handling and inspection, for which lower maintenance costs are indicated. Metering is provided to maintain a minimum of satisfactory records and test data. Each panel is provided with an ammeter. Each bus is provided with a voltmeter to register phase voltage and a set of voltmeters to register phase to ground voltages to indicate the presence of grounds. There is no necessity to have a breakdown of energy requirements, consequently, kilowatt-hour meters are provided only for main transformers to indicate total consumption. To maintain a simple method of recording load on the transformers, each KWH meter is provided with a KVA thermal demand attachment. Relay protection, other than that involved in automatic bus transfer, is in accord with standard practice. Particular attention is given to the types and ratings of the relays provided to insure that coordination can be accomplished to the maximum possible degree. This normally results in the use of relays in the 480-v switchgear instead of direct trip overcurrent devices. It is felt that this is one of the most important aspects of design in the system, as much additional reliability can be insured with no additional investment in equipment and only a relatively small amount of additional engineering effort. The relaying scheme for automatic transfer will be discussed separately.

Switchgear is normally of the indoor type and is housed in a building. Two reasons justify this action: (1) Cost of weatherproofing sizable installations approaches or exceeds the cost of a building, and (2) maintenance or inspection can be scheduled independently of weather conditions.

Switchgear interrupting requirements are reviewed carefully, and it is usually found that 2400-v transformers should be limited in size to 3000 KVA and 480-v transformers limited to 750 KVA. These two transformer sizes limit the interrupting duty to what we believe is the most economical values; i.e., 50,000 KVA for 2400-v switchgear and 25,000 amp for 480-v switchgear.

As most of the installations are not designed to operate with the transformers in parallel, it is considered necessary to provide a positive interlock system. This is accomplished either by electrical interlocks or a key operated mechanical system.

Relaying Scheme for Automatic Transfer of Load in Switchgear

For several years we have recognized that a secondary selective system is the most satisfactory type for our use. To make the system most satisfactory, it is necessary to provide an automatic system of transfer. The scheme is basically simple, however, our experience to date has demonstrated there are some problems which must be solved. Present designs attempt to overcome these, but we foresee the possibility of discovering additional factors in the future, since our present calculations are based on a more or less static basis rather than a dynamic basis. The following discussion describes our present system of accomplishing automatic transfer.

Conditions under which transfer should occur are as follows:

(a) Loss of voltage on one bus.
(b) Failure of one of the primary feeders.
(c) Failure of one of the transformers.
(d) Manual switching.

Conditions under which transfer should not occur are as follows:

(a) Loss of voltage on all busses.
(b) Temporary voltage dips on one or both busses.
(c) Bus faults.

Basically the system is initiated by time delay undervoltage relays, which operate when the voltage drops below 85 per cent. Transfer should occur provided that a fault has not occurred on the main bus or a branch circuit, and voltage has not been lost on the other bus. Fig. 2 illustrates this basic scheme. When voltage is lost on bus A, the No. 27 (undervoltage) relay operates at some later time and initiates the tripping of breaker A and closing of the bus tie breaker C by energizing control relay 83. If, however, voltage on both busses has been lost, the instantaneous undervoltage relay 27 I on bus B operates and prevents operation of relay 83 and the transfer of load.

Past experience has indicated that a residual voltage exists on a bus feeding motors when the bus is disconnected from the source. Should a transfer occur when this residual voltage is substantially out of phase with the source,

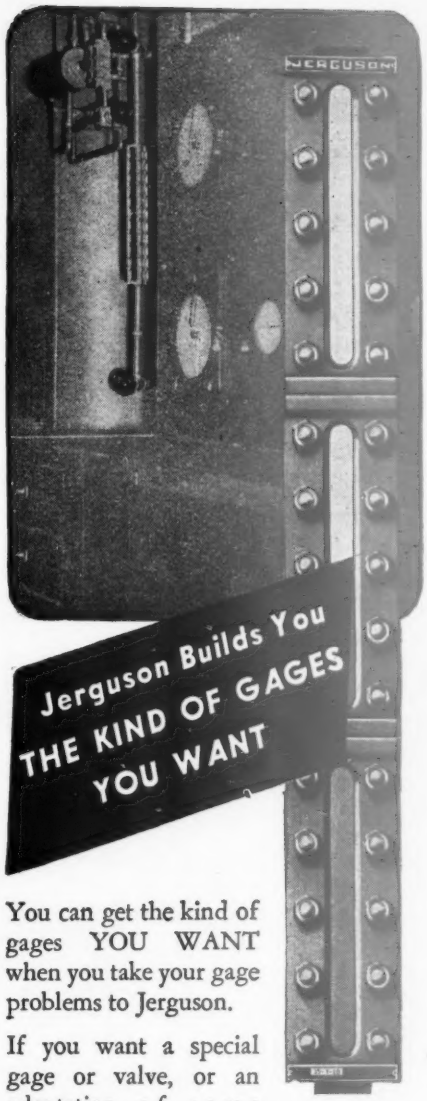

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FIG. 2. BASIC SCHEME (right) for automatic transfer system.

FIG. 3. BASIC SCHEME (lower right) for automatic transfer backup protection.

FIG. 1. ONE-LINE DIAGRAM of the electrical facilties discussed in this article.

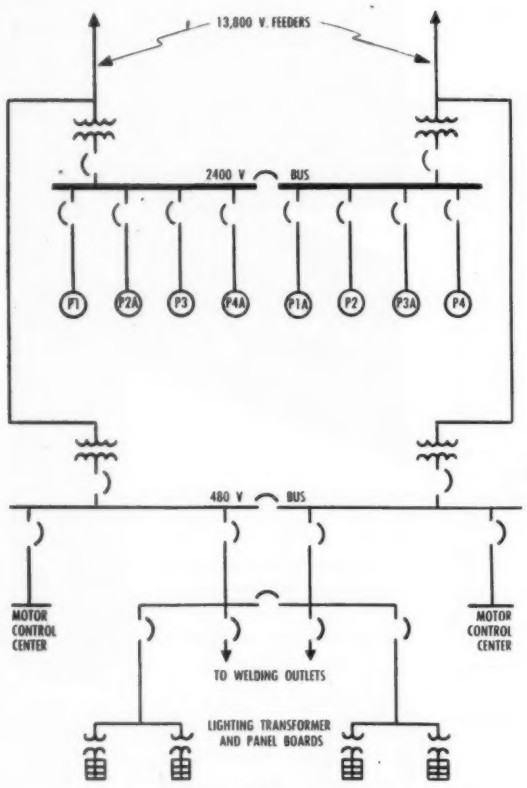

FIG. 1.

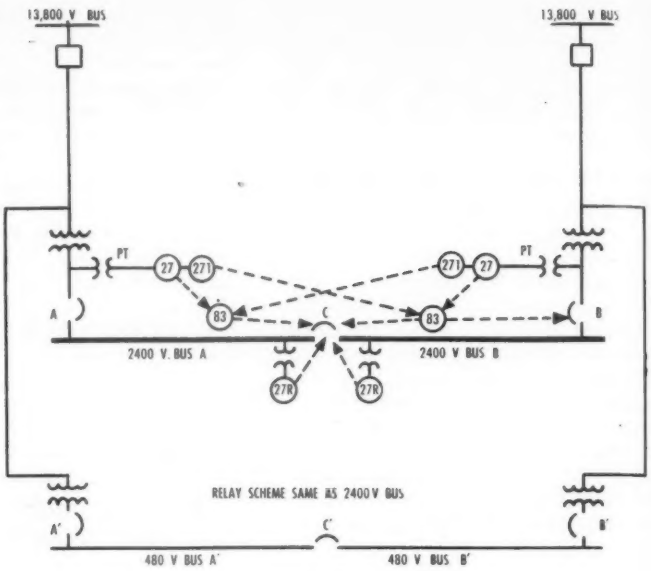

FIG. 2.

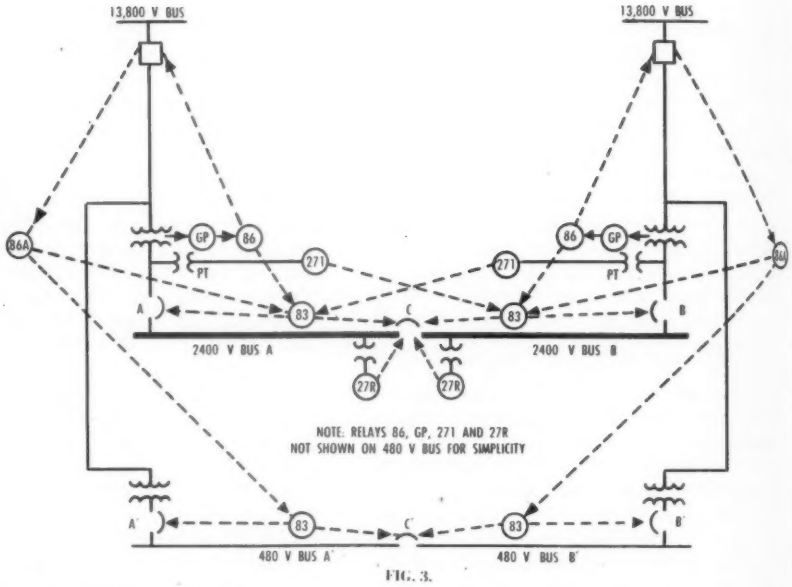

FIG. 3.

the resulting transient currents may be sufficient to trip overload relays. Consequently, it has been found necessary to provide an additional relay No. 27 R to determine when the voltage drops to 25 per cent and prevent automatic transfer until this condition is reached.

This basic scheme of transfer due to loss of voltage will satisfy all of the previously mentioned conditions. As mentioned, however, a gas pressure relay is provided to operate on a transformer internal fault, and a control cable must be provided to allow this relay to trip the circuit breaker controlling the primary 13,800-v feeder. It, therefore, becomes a simple matter to provide a backup system to initiate automatic transfer for the conditions of (b) failure of one of the primary feeders and (c) failure of one of the transformers. This backup system substantially reduces the time required to transfer.

Fig. 3 illustrates this scheme. Operation is as follows when a feeder failure occurs and overcurrent relays trip the 13,800-v circuit breaker: Auxiliary contacts on the 13,800-v circuit breaker energize control relay 86 A, which trips the circuit breaker on the transformer secondary and initiates transfer through relay 83. Relay 27 I is also used in this scheme to determine if voltage is available on the other bus, and relay 27 R prevents transfer until the residual voltage has decreased to 25 per cent.

The operation is as follows when a transformer failure occurs: Gas pressure relay GP energizes relay 86, which trips the 13,800-v circuit breaker and energizes the transfer relay 83. When the 13,800-v circuit breaker trips, relay 86 A is energized on all other switchgear groups utilizing the feeder and transfer of those groups is initiated.

Transfer scheme is arranged such that manual operation is required to restore normal operating conditions. To accomplish this a key operated "Automatic-Manual" switch is provided that must be set to the "Manual" position. The control switches on the transformer secondaries can be then used to close incoming circuit breaker and simultaneously trip bus tie circuit breaker.

A manual transfer of load can be accomplished, when the "Auto-Manual" switch is in the "Manual" position, by proper operation of a key operated selector switch and the control switch on the bus tie circuit breaker. In this case, closing the bus tie breaker automatically trips the incoming circuit breaker selected.

Conclusion

This discussion of some of the details of the electrical system for a typical modern process unit should illustrate that the system is more or less standard industrial practice. As a result of the demand for reliability of electric power in a petroleum process unit, however, a number of special applications have been devised. Always these special applications have been on the basis of minimizing the effect of electrical system troubles on the operation of the process. As a result, we feel confident that our present design practices will give reliability commensurate with the demands of the refinery processing units. ★ ★ ★

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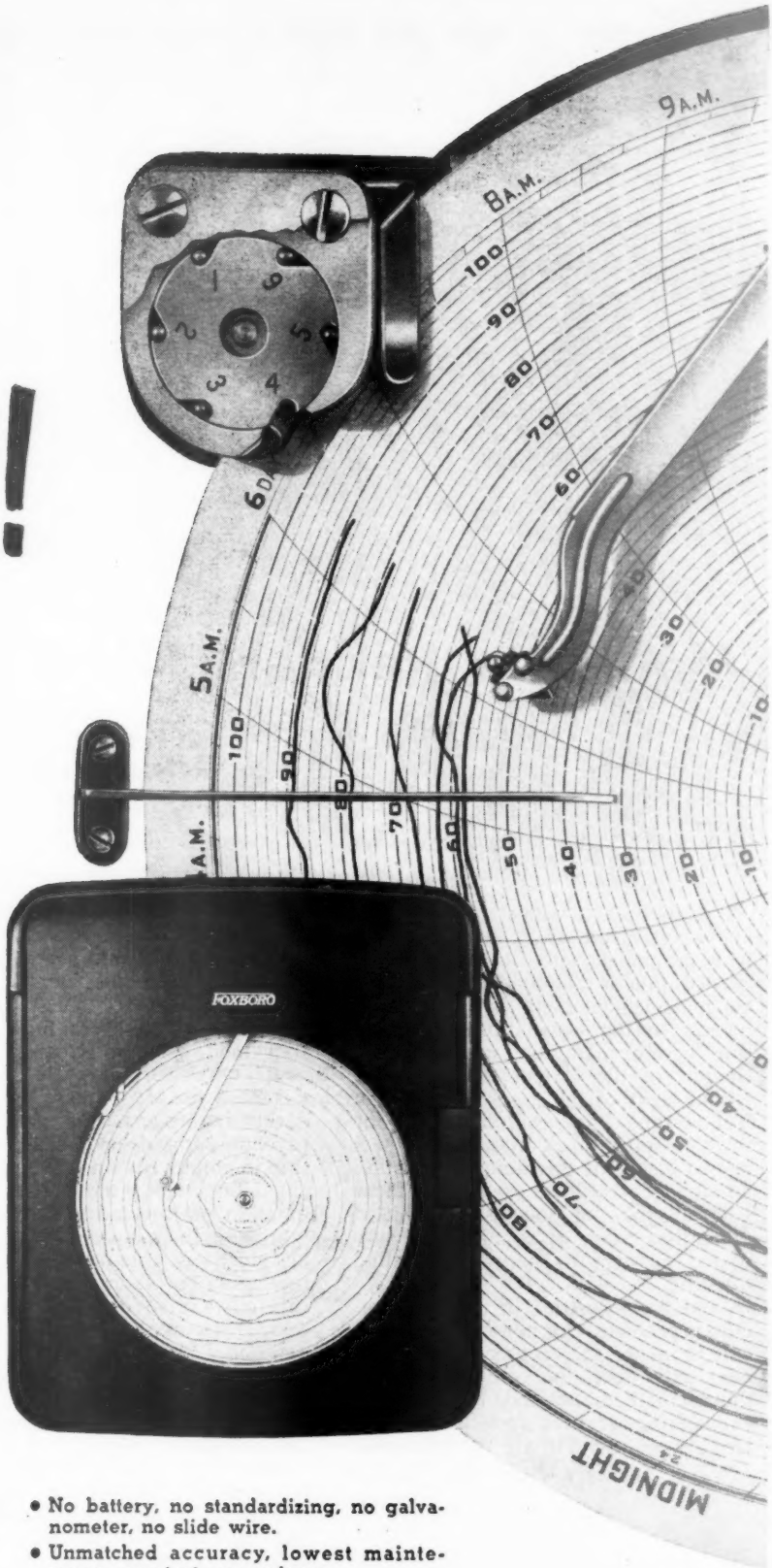

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F. L. HUTTON, right, was presiding chairman of industrial relations forum; F. M. Butler is at left.

F. B. ODASZ, Paul Williams (WPRA technologist), and James C. Reed "talk it over" after meeting.

Mountain Refiners Show Problem Solutions

ARCH L. FOSTER*

APPARENTLY the fastest growing professional refining group in the realm of the Western Petroleum Refiners Association, a two-day regional meet at Casper, Wyoming, September 24-25, had crammed into it more hard-headed, practical technical and personnel management facts than have been offered to the association's membership there in many long moons. In the shadow of the Casper range, almost within sight of the reported snows in Yellowstone Park, within "smell" of the high-sulfur black crudes, and others not so black, of this unique mountain empire the refiners swapped ideas galore, spoke of successes, admitted difficulties chary of solution and suggested answers to many a puzzling question.

And the industrial, or employee relations problems are none the less difficult than are the technical, engineering, and operating problems, even though mathematics and chemistry and engineering are more applicable to material problems than are the principles of psychology and fair play to negotiations with employees in refineries.

Communications and methods therefor appear to be of increasingly primary importance, no matter whether it calls for radio to unite scattered groups of workmen over an extended area, or the transmission of ideas, principles, and proposals to several hundred plant staff men. Richard Crow of Continental Oil discussed in considerable detail how his department goes about developing plant staff leaders; the psychology of development of leadership in employees who give promise of capabilities along those lines. A combination of directed activities and of "throwing them out on their own" may be given as rule-of-thumb principle that must be planned and carried out carefully to give some assurance of success. Discussion indicated also the idea and belief that without trained leadership within the staff, the organization cannot function efficiently. Earlier-day hit-and-miss methods of bringing along under-leaders, some of whom are to become top leaders eventually, are "out the window." One of the fundamental principles of human relationships is indicated by Cities Service's industrial relations director Fred M. Butler's title, "Employee Relations by Opiates or Incentives." Pointing out the essential fallacy of utilizing the opiate route to alleviate a headache without any curative reaction, even with aggravational results, Butler outlined methods of approach that show the best promise for obtaining the results desired by both labor and management.

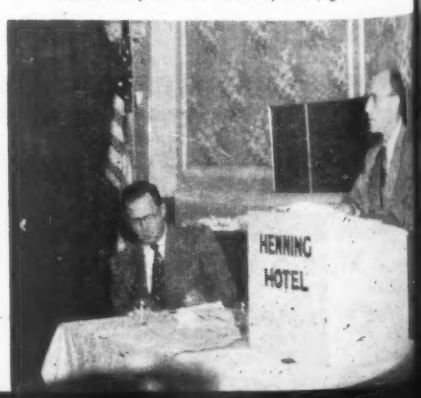
Audible or visual signals in a small refinery may be adequate for communication between members of a working group but are not satisfactory for a large plant or one scattered over considerable territory, C. L. Rose pointed out. For such situations as Standard of Indiana's sprawling Casper refinery the two-way radio solved the problem best. A base station with two remote controls, one in the machine department and one in the labor and transportation office is the nerve center. Add to this mobile units on service trucks, two "flat beds with tail lifts" and five others in different departments and the original installation or system was completed. Subsequently other mobile units were fitted, one each for the welding, labor, labor-and-lube shift foremen and for light oils shift foremen, and finally another remote control for the base station was installed at the watchman's house at the main gate of the plant. The base station, at the plant vacuum still was connected to that unit's emergency lighting system to insure uninterrupted power supply.

This communications system is used for every conceivable purpose, and the

*Editor, Refining & Petrochemical Edition.

ED ZOBLE, director, industrial relations, The Texas Company, Casper, discusses a "hot point" during first day's forum.

J. C. REED, right, gives with "know-how" of planned maintenance for mountain refineries; R. E. Howe, left, presided.



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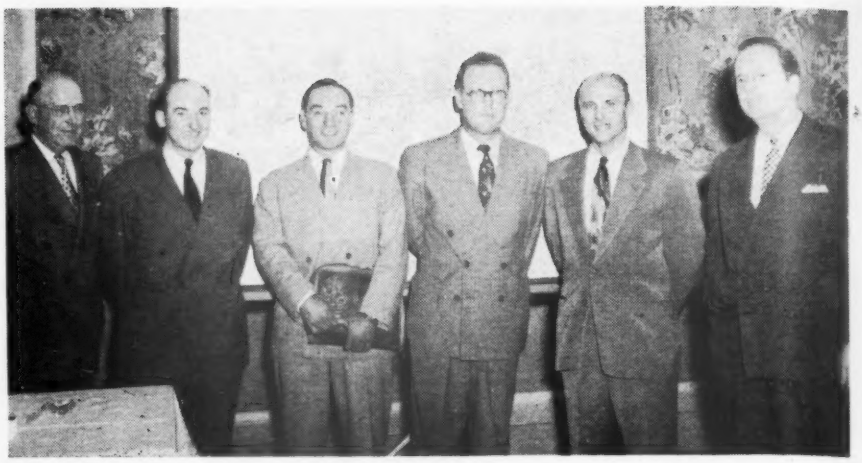

SPEAKERS on second day of WPRA meeting in Casper, Wyoming, September 24-25 were C. L. Rose, general foreman, electrical department, Standard Oil Company (Indiana), Casper; J. S. Corlew, technical assistant, Sinclair Refining Company, Sinclair, Wyoming; F. B. Odasz, assistant director, technical service, Husky Oil Company, Wyoming; J. C. Reed, vice president, procon division, Universal Oil Products Company, Des Plaines, Illinois; John W. Teter, director, catalysis research division, Sinclair Research Laboratories, Harvey, Illinois.

INDUSTRIAL relations forum panel, Casper WPRA meeting, September 24 were W. H. Montgomery, manager industrial relations, Socony-Vacuum Oil Company Inc., New York City; R. R. Crow, director, personnel development Continental Oil Company, Houston, Texas; F. M. Butler, director, industrial relations, Cities Service Oil Company, Bartlesville, Oklahoma.

time-saving appears incredible when considered in terms of non-radio days experiences. In normal use "it functions smoothly and easily—so smoothly that in a short time its effect is scarcely noted, but under emergency or abnormal conditions it can and should achieve spectacular results," said the speaker in summing up its value in an extended, busy plant.

Statistical Methods and Management

Modern statistical methods may be applied in literally every department of a refining company, says Frank Odasz, Jr., assistant director of technical services for Husky Oil Company. In nine company departments, including traffic and finance, Odasz mentioned 29 major applications of statistical methods for the simplification and efficiency-boosting of the department's operations. Engineering is credited with four applications, equipment design, process operating conditions, quality specifications and evaluation of new processes. Manufacturing can use these methods in quality control and process inspection; research and development has five points to be filled by these methods; sequential analysis, prediction equations, experimental data analysis, experiment planning and

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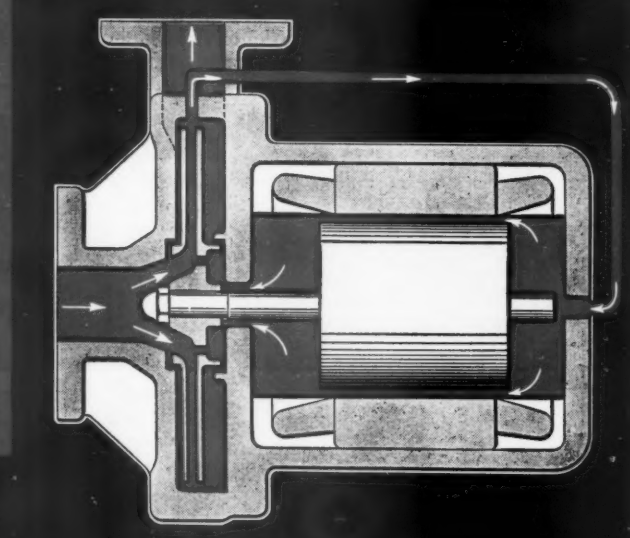

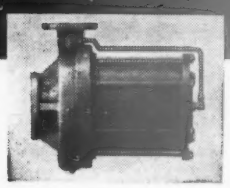

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These methods eliminate or minimize at very least the haphazard, hit-or-miss methods generally employed to reach conclusions, methods that do not have any accurate routine for measuring the reliability of an estimate.

And this is the field of endeavor for statistical methods; "Statistics will never improve your data," says Odasz, "it only improves your estimates; . . . call in an expert when help is needed." An instance is given wherein management found by these methods that the company had an 80 per cent chance to make 91 per cent on an investment; but only a 20 per cent chance to make 131 per cent!

Catalytic Reforming

Said to be outstanding among naphtha-reforming catalysts is the new platinum-bearing catalyst, RD-150, developed by Sinclair Research Laboratories, Inc., and Baker and Company, Inc., and now having a 16,000 bbl per day reformer built for its use at Sinclair Refining Company's Marcus Hook, Pennsylvania, refinery. As outlined by J. W. Teter at the Casper meeting, who co-authored the paper with B. T. Borgerson and L. H. Beckberger of Sinclair Research, the two major advantages of this catalyst are (1) a high ratio of paraffin cyclization (aromatization) and (2) the ability to be regenerated with a stream of "diluted" air. With high aromatization ratio the yield-octane rating relationship is high and advantageous, especially when processing highly paraffinic stocks, the most difficult to upgrade in quality and high yields simultaneously.

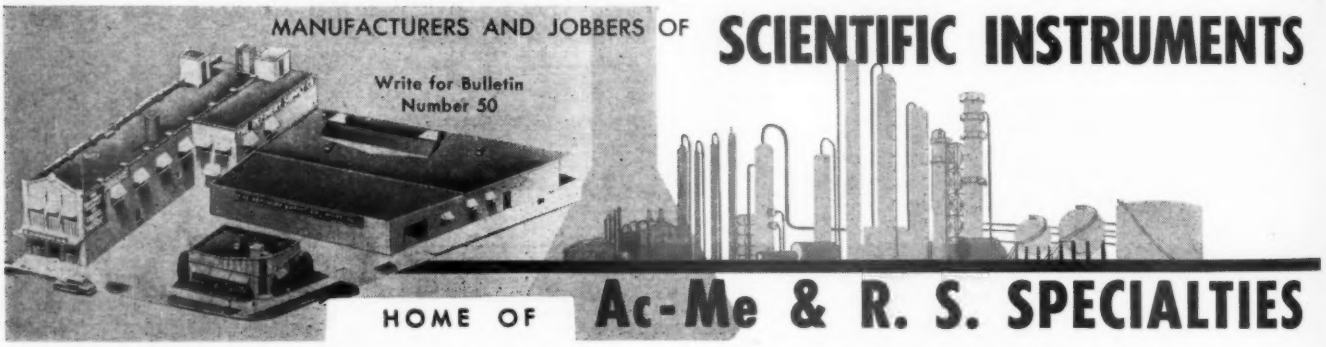
Operating on various feedstocks with paraffin contents ranging from 34 per cent to 65 per cent, and so operating as to produce reformate of the same clear (neat) and leaded octane range (clear 85 to 95 O. N. with 3 cc. TEL, 94.6 to 99.6 O.N.) yields ranged from 91.7 per cent at 85 O. N., to 85.8 per cent at 95 O. N. for a low paraffin Venezuela stock. For a 65 per cent paraffin Kuwait stock the corresponding yields are 85.6 per cent for 85 O. N., to 75.6 per cent for 95 O. N. These results are obtained on continuous operation at 500 psig pressure, Teter stated.

At 200 psig on regenerative operation the yields are better for the same stocks and "neat" octane number ratings. Venezuela showed 91.8 compared to 91.7 for continuous, 500 psig operation, and 86.8 per cent as above 85.8 for the continuous job. Kuwait stock shows even better at 200 psig regenerative runs, 86.8 per cent over 85.6 (85 O. N.), and 81.2 per cent as above 75.6 when making 95 octane number "neat."

For aromatics production, the Venezuela stock tested shows 14 per cent benzene, 8 per cent toluene from a C_6 fraction; 28 per cent toluene and 15 per cent mixed xylenes from a heptane fraction, and 4 per cent toluene, 33.4 per cent xylenes and 18 per cent C_9 aromatics from octane fractions. The C_9 product will contain trimethyl benzenes, methyl-ethyl benzenes, n- and i-propyl benzenes (i-propyl benzene is cumene). As high as 57 per cent benzene is made from a California C_6 (hexanes) fraction, 46 per cent of toluene from the heptane fraction and 50 per cent xylenes from the octane cut. Even Mid-Continent stock shows a 50 per cent yield of benzene from the hexanes stream from the crude.

Catalyst regeneration is carried out by dropping the reactor pressure and purging the system with an inert gas (flue gas?), leaving the inert gas in the system and recirculating it with a compressor while adding a measured proportion of air to burn off the carbon collected on the catalyst. Afterward hydrogen or recycle gas is begun in recirculation up to mild pressures and operation resumed by introduction of naphtha and processing "at mild conditions," to get under way again.

In general, catalyst cost per barrel of reformate ranges from 3 cents to 10 cents, depending on feed stocks, octane produced and other factors. An overall operating cost of 21 cents per bbl, ½ cent per gal, was presented by the authors as typical. The catalyst is manufactured by Baker and Company, at Newark, New Jersey, and process design is offered by M. W. Kellogg Company with or without regenerative facilities. * * *



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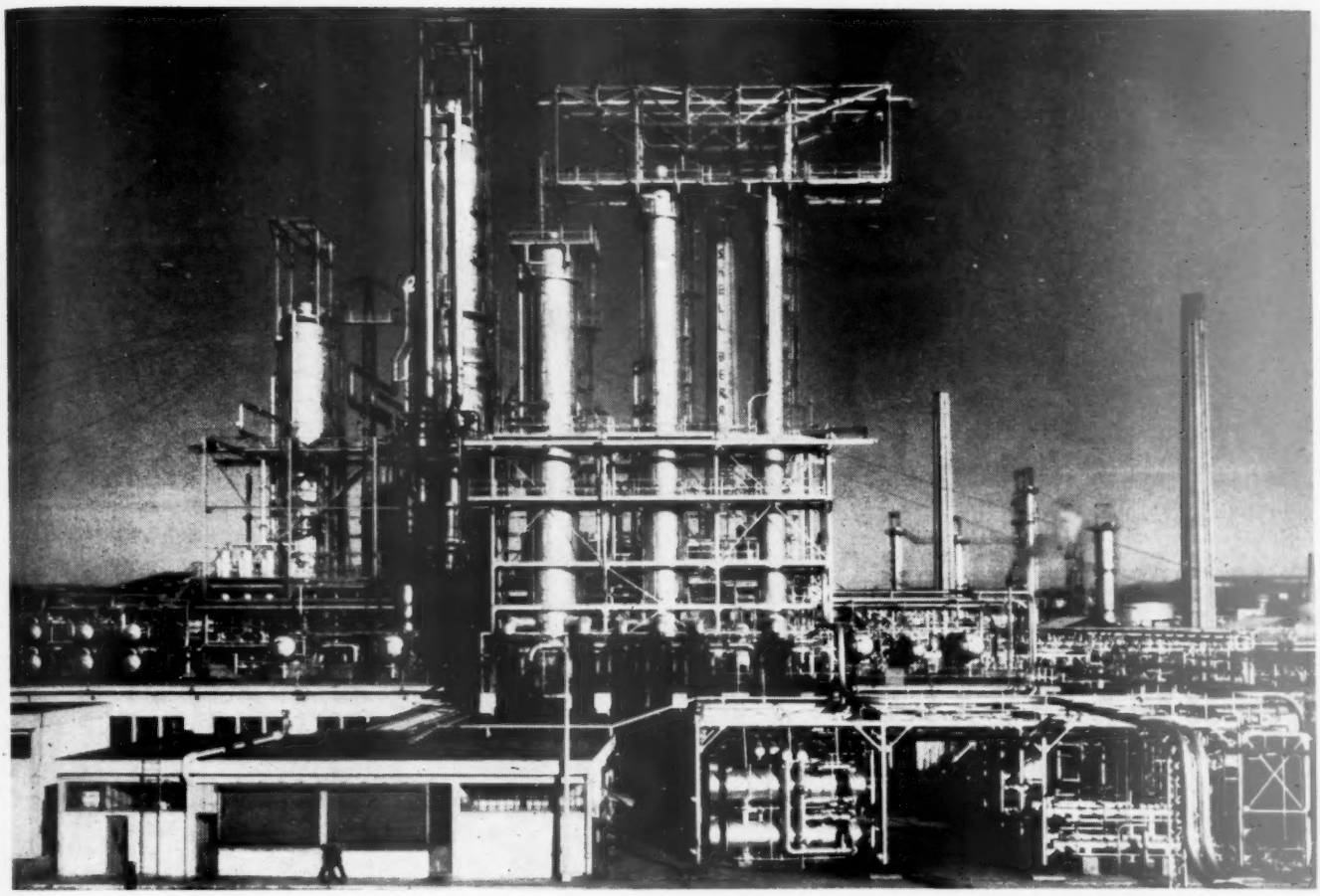

Distillation and reforming units at Shell's Berre, France, plant.

French Plants Make Alcohols, Solvents, Detergents

Isopropyl alcohol, acetone, "Teepol" (detergent from wax) produced in two new French petrochemical plants, from the refinery olefins

V. S. SWAMINATHAN

In 1935 Shell Chemical Corporation erected installations at Martinez in California for the manufacture of isopropyl alcohol and acetone from propylene. The following year witnessed the construction of a plant at Dominguez near Los Angeles for making derivatives from acetone such as diacetone alcohol. By 1939 this corporation's units were producing methyl isobutyl ketone. All these solvents have also been in production for an appreciable period at Stanlow, Cheshire, England.

In October 1951, a plant, operated by Societé Shell Saint-Gobain, started manufacturing "Teepol," a synthetic detergent, at Petit-Couronne near Rouen. While seeking in the inter-war period of methods of preparing higher alcohols from unsaturated long-chain molecules the idea was conceived by the research workers of the Royal Dutch-Shell Group in Amsterdam that synthetic wetting agents could be manufactured from them. In due course, a process was developed for the commercial production of synthetic wetting and cleaning agents from crude paraffin was procured as a byproduct of lube oil refining. This wax consists almost wholly of straight chain molecules of great length. By means of the cracking process developed for this purpose the chains are shortened and olefines obtained from the paraffin molecules, which, in contrast to the olefines from cracked gases, have a longer chain and are not gaseous but liquid at normal temperature and pressure. Industry uses these as base material for the production of synthetic detergents and wetting agents.

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In 1939 a start was made with the building of the first Teepol plant at Stanlow in England, and it was put into operation early in 1943. In mid-1949 a second installation started producing at Pernis near Rotterdam, while in the same year construction of a similar unit was begun at Petit-Couronne in France. In short, utilizing the basic process which proved successful at the Shell refineries in England and Holland, but incorporating operational experience gained with each, this new installation, with a designed annual capacity of 25,000 metric tons, brings a proved and versatile detergent to an even wider industrial and domestic market. Capacity

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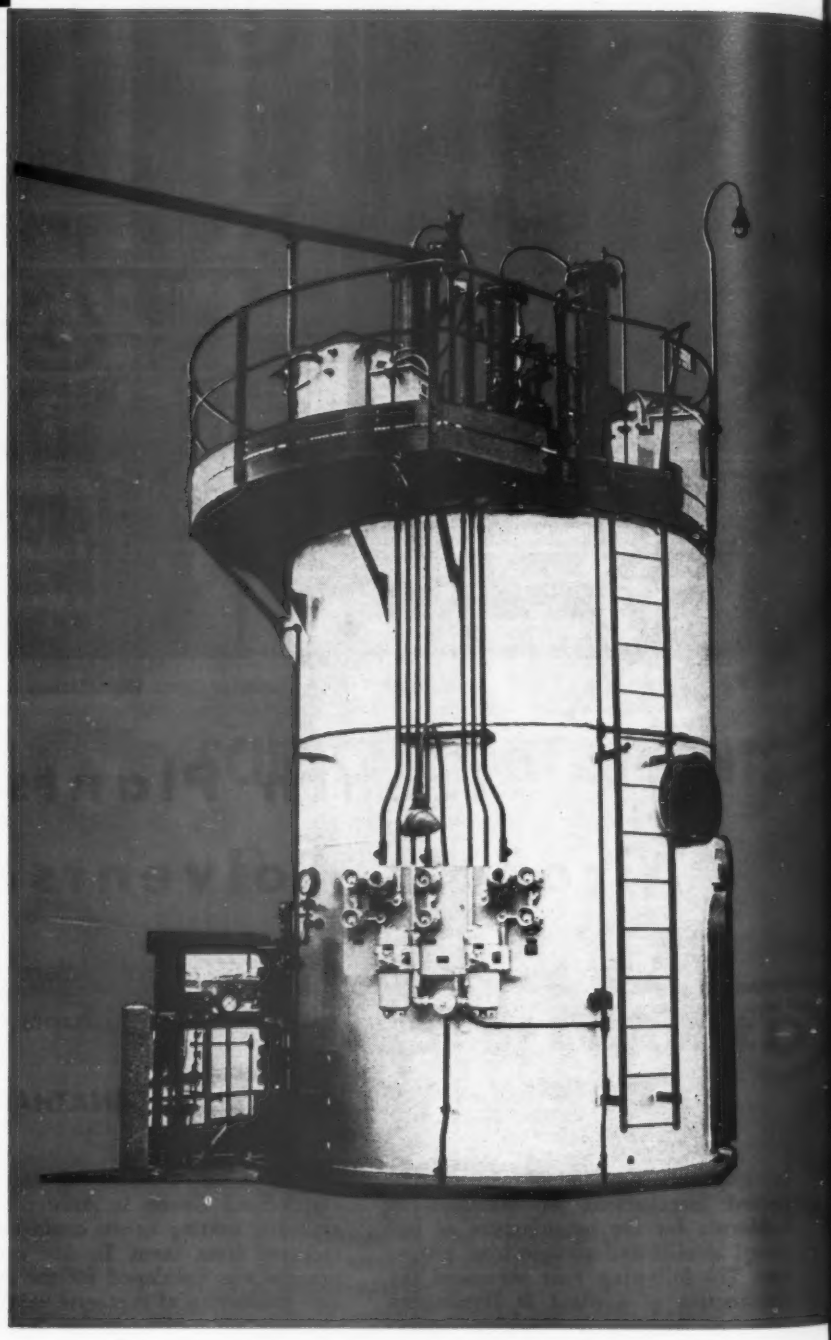

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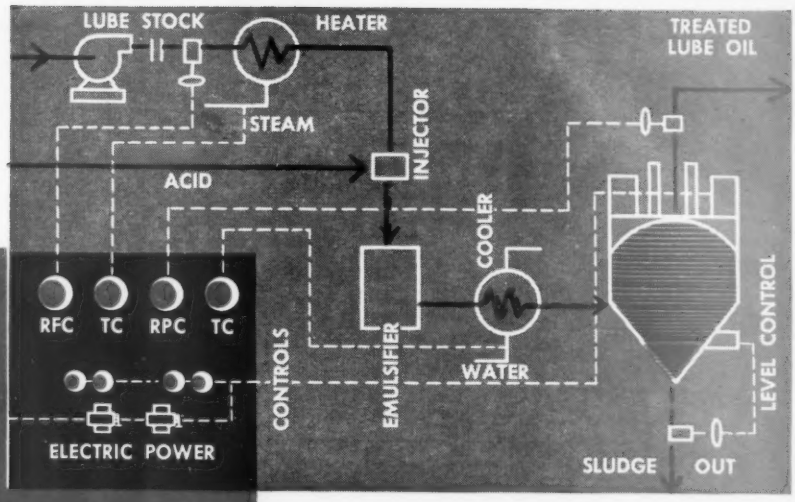

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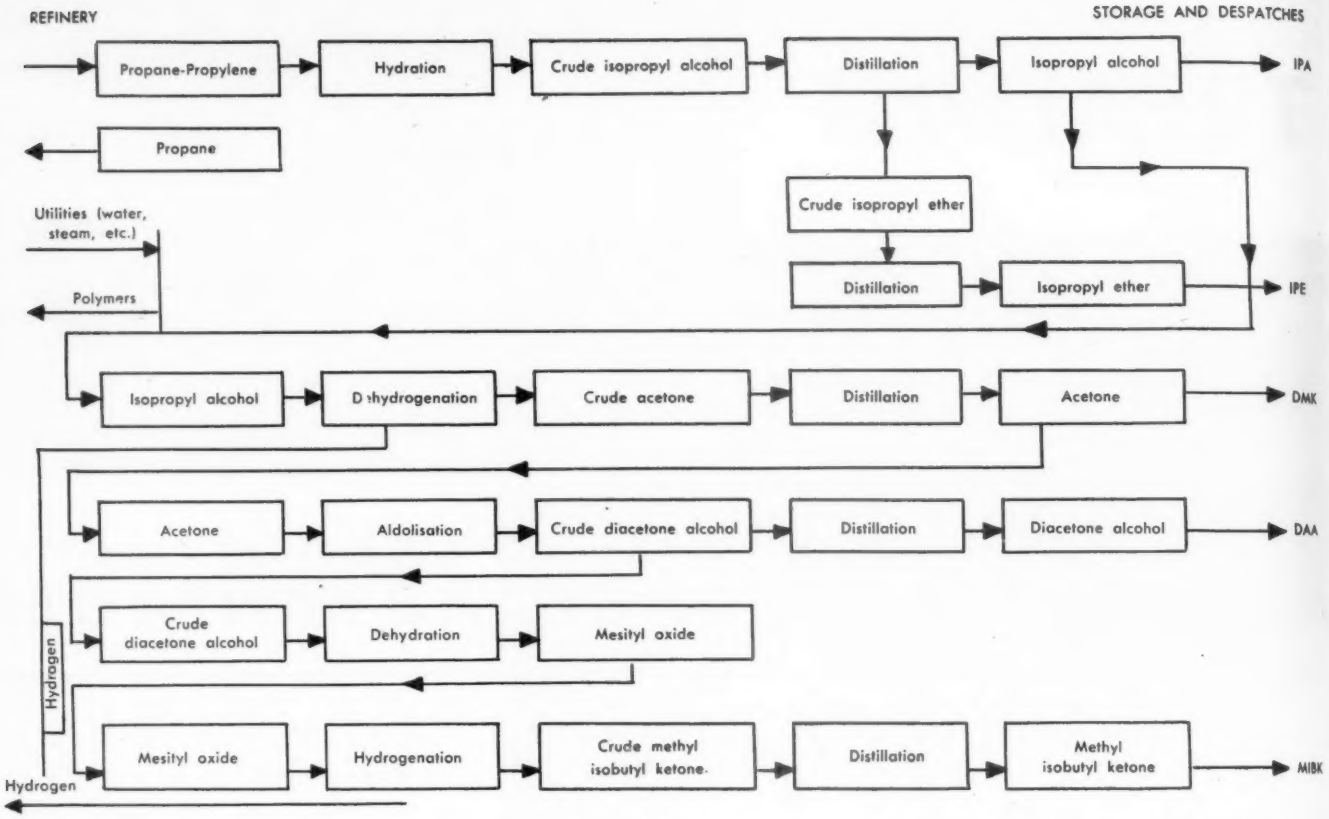


DIAGRAMMATIC flowchart of process for synthesizing alcohols, ethers and ketones from propylene olefin stream, in Shell's plants.

of this Teepol plant is being enlarged.

Sixteen months following the starting of the Teepol plant, Shell Saint-Gobain placed another petrochemical unit on stream at Berre. The Berre chemical installation, first in France to produce acetone from petroleum, was built at an outlay of $4,000,000, of which barely 3½ per cent was paid out in foreign currency for special equipment not obtainable in France, and 6 per cent for design work by American, British, and Dutch specialists.

Shell-Berre is a combination of Shell and Saint-Gobain, one of France's oldest and largest producers of heavy chemicals. Prior to the construction of the chemical plant at Berre propylene from the adjoining refinery belonging to the Compagnie de Raffinge Shell Berre was used only for heating. This petrochemical unit receives sulfuric acid from a fertilizer factory of Saint-Gobain at near-by Port-de-Bone. The fresh acid is employed for the hydrolysis operation at Berre, and the spent acid returned for producing superphosphates at Port-de-Bone.

Propylene to Ketones, Alcohols

Raw material utilized is the propane-propylene stream, a byproduct from Shell-Berre refinery obtained in the course of normal reforming and cracking operations. To facilitate flexibility in its reception and consumption storage under pressure is provided at the plant in horizontal cylindrical tanks. The current aggregate annual output capacity is 7500 metric* tons, but the plant has been built in such a way that the respective quantities of the various solvents manufactured can be adapted to meet changing market needs. The range of solvents produced includes:—

Ketones: acetone
methyl isobutyl ketone (MIBK)
diacetone alcohol (DAA)
Alcohols: isopropyl alcohol (IPA)
methyl isobutyl carbinol
Ether: isopropyl ether (IPE)

The C_3 fraction contains propane and propylene only. It is allowed to react with sulphuric acid in which the propylene is absorbed, forming alkyl esters, while the propane is unattacked. The acid solution is separated from the propane which after suitable treatment is used as fuel; the alkyl esters are hydrolysed with water for the production of isopropyl alcohol, which is separated from the acid by stripping with steam. Isopropyl alcohol is purified by distillation.

By heating to high temperatures under carefully controlled conditions, and in specially designed equipment, the isopropyl alcohol is broken down into the corresponding ketone together with pure hydrogen. And under suitable conditions acetone is converted into diacetone alcohol which, in its turn, may be made into methyl isobutyl ketone via mesityl oxide. All of these products are purified by distillation.

Reactions involved in the preparation of isopropyl alcohol are as follows:

$$CH_3-CH=H_2+H_2SO_4 \rightarrow \begin{matrix}CH_3\\CH_2\end{matrix}\!\!\rangle CH.HSO_4$$

Isopropyl hydrogen sulfate

$$2CH_3-CH=CH_2+H_2SO \rightarrow \left(\begin{matrix}CH_3\\CH_3\end{matrix}\!\!\rangle CH\right)_2 SO_4$$

Diisopropyl sulfate

$$\begin{matrix}CH_3\\CH_3\end{matrix}\!\!\rangle CH.HSO_4+H_2O \rightarrow \begin{matrix}CH_3\\CH_3\end{matrix}\!\!\rangle CHOH+H_2SO_4$$

Isopropyl alcohol

$$\left(\begin{matrix}CH_3\\CH_3\end{matrix}\!\!\rangle CH\right)_2 SO_4+2H_2O \rightarrow 2\begin{matrix}CH_3\\CH_3\end{matrix}\!\!\rangle CHOH+H_2SO_4$$

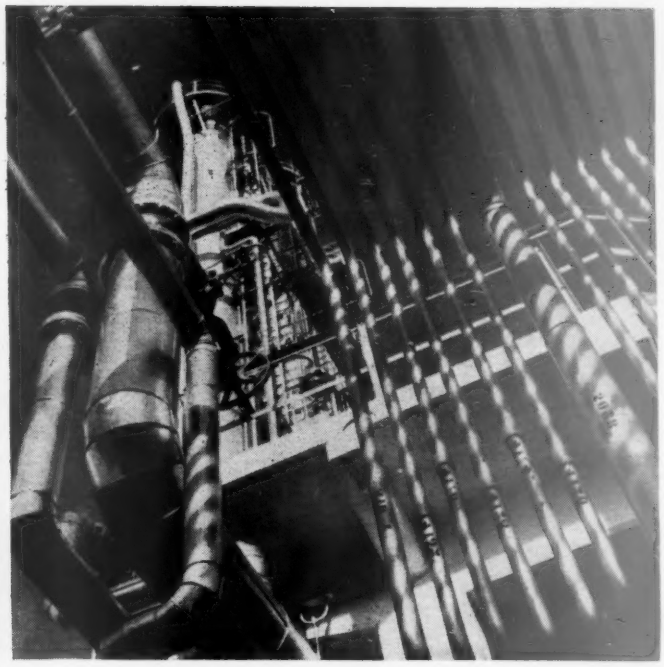
Isopropyl alcohol

Ketones via Catalysts

The conversion of isopropyl alcohol into acetone is represented thus:—

*Metric ton = 2204+ lb. approx.—Ed.

STORAGE tanks for intermediate and finished products at Berre plant.



FRACTIONATION columns and piping in Shell acetone-and-solvents at Berre; note identifying marking on piping.

$$CH_3)CHOH \xrightarrow{\text{Catalyst}} CH_3)C=O + H_2$$

Acetone

The reactions involved in preparing methyl isobutyl ketone from acetone are:

$$CH_3)C=O + O=C(CH_3)_2 \xrightarrow{\text{Catalyst}} CH_3-\overset{O}{\overset{\|}{C}}-CH_2-\overset{OH}{\overset{|}{C}}(CH_3)_2$$

Acetone — Diacetone alcohol

$$CH_3-\overset{O}{\overset{\|}{C}}-CH_2-\overset{OH}{\overset{|}{C}}(CH_3)_2 \xrightarrow{\text{Catalyst}} CH_3-\overset{O}{\overset{\|}{C}}-CH=\overset{CH_3}{\overset{|}{C}}-CH_3 + H_2O$$

Diacetone alcohol — Mesityl oxide

$$CH_3-\overset{O}{\overset{\|}{C}}-CH=\overset{CH_3}{\overset{|}{C}}-CH_3 + H_2 \xrightarrow{\text{Catalyst}} CH_3-\overset{O}{\overset{\|}{C}}-CH_2-\overset{CH_3}{\overset{|}{C}}H-CH_3$$

Mesityl oxide — Methyl isobutyl ketone

Isopropyl alcohol is obtained in the form of an azeotropic mixture containing 87 per cent alcohol. The acetone obtained is extremely pure, over 99.6 per cent. The diacetone alcohol put on the market is very pure, but if it is for conversion into methyl isobutyl ketone, the specifications are less stringent, as some of the impurities will in any case be eliminated during the final distillation of MIBK. The purity of the latter commercial product is also very high, exceeding 99 per cent. Very close control over all the reactions is essential, and to this end an elaborate system of automatic control of the process is incorporated in the design of all units. The crude and finished products are followed at all stages of manufacture and storage by determinations of characteristics on all installations or at the laboratory.

Byproduct Hydrogen Used

Propane from the C_3 stream, following purification and washing with soda, is returned to the Shell Berre refinery.

Hydrogen obtained as byproduct in the manufacture of acetone is subsequently utilized in the preparation of methyl isobutyl ketone.

The ketones include low, medium and high boiling point solvents; their range, coupled with their good solvent powers, enables them to be used individually or in mixtures for various types of surface coatings. The alcohols also find wide applications in the surface coating industries, for solvent mixtures containing an alcohol frequently dissolve far larger quantities of solids than a simple solvent. Lastly, isopropyl ether is a valuable solvent in many processes where its lower volatility renders it preferable to ordinary ethyl ether.

Acetone, a low boiling point ketone, is employed in industry as a solvent for the manufacture of nitrocellulose lacquers, aeroplane dopes, paint removers, transparent paper, photographic film, celluloid, leather cloth, acetate rayon and explosives—to give but a few of its many solvent applications. It is important in the extraction of many drugs and pharmaceutical items. As a raw material it is employed in the production of chloroform, synthetic perfumes and plastics, including the transparent types from which aircraft windshields are made. It is, furthermore, used for the safe storage of acetylene under pressure.

Methyl isobutyl ketone falls into the class of solvents with medium boiling points, and like actone and methyl ethyl ketone, possesses high solvent powers for surface coating work and for extraction processes, besides being valuable as a chemical intermediate.

Lacquer Solvent, Brake Fluid

Diacetone alcohol is a most versatile solvent of the high boiling type for use in finishes such as nitrocellulose lacquers, where judicious incorporation of this ketone aids flow of the film and obviates "blushing." One of its most important industrial applications, however, is in the manufacture of hydraulic brake fluids. Diacetone alcohol is one of the few organic materials which offer complete miscibility with castor oil at high and low temperatures, a low freezing point and non-corrosive action, and it has the minimum effect on the rubber parts of brake mechanisms.

Isopropyl alcohol, besides its outlet in the lacquer field, is employed in sev-

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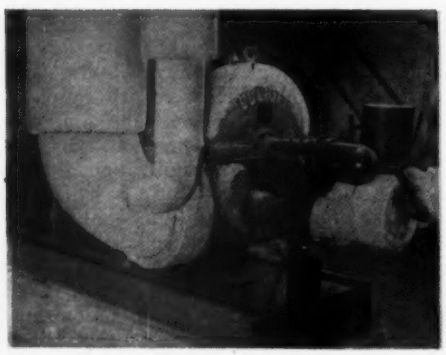
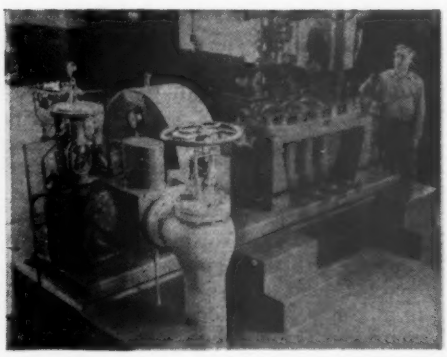
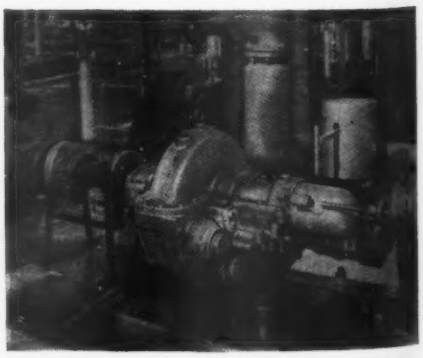
Clean, simple lines reflect the advanced engineering and manufacturing skill that has gone into building this modern, efficient turbine. It's the turbine that offers *everything* — adaptability, reliability, economy and a recognized reputation among plant engineers as one of the finest, most dependable turbines available anywhere.



Elliott 360-hp, 3550-rpm turbine driving a boiler-feed pump in a paper mill, exhaust steam being used in process.



Elliott 500-hp turbine driving a hydraulic system pump in a steel mill. Turbine maintains constant pump discharge pressure.



One of a group of Elliott turbines driving lean oil pumps in a cycling plant, where reliability is especially important.

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A standard turbine— yet "tailor-made" to your requirements

Elliott Turbines can be adapted to practically any operating condition or service

That's because these powerful, compact turbines are designed to give you the advantages of custom-built adaptability at savings achieved through mass production of standardized parts. A wide variety of permissible modifications are possible. For instance . . . five sizes of YR turbines cover the entire range of capacities up to 2000 hp, speeds from 800 to 7000 rpm and back pressures from 4 in. Hg to 250 psig. Standard designs of rotor, governor, bearings, bearing cases, steam chest, governor valves and governor linkage are used throughout. In the case of higher pressures and temperatures up to 850 psig and 900 F, materials for steam parts may be changed from cast iron to steel.

Here are a few of the design highlights that are included in Elliott turbines:

Air-wall labyrinth seals to protect bearings from contamination without rubbing contact.

Centerline support to provide constant alignment under any operating condition.

Stainless steel spray coating under packing glands to eliminate corrosion of the shaft.

Choice of many governors to meet specific control requirements.

Liner type bearings to eliminate the need for scraping and fitting.

Packing glands removable without raising turbine upper half casing to simplify inspection and maintenance operations.

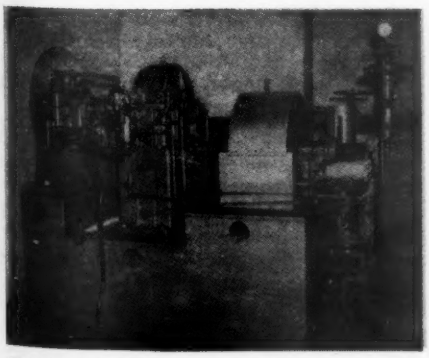
Stainless steel buckets and shroud to assure maximum life and continued high efficiency.

These and many other features are *standard* in Elliott turbines. They are the result of years of practical experience in the application of turbines to hundreds of different types of plant equipment and to many different types of operating and steam requirements.

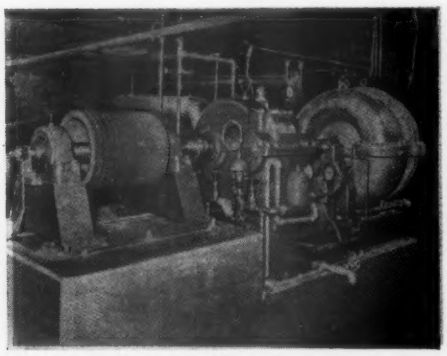
Full details on Elliott Mechanical Drive Turbines can be obtained from your local Elliott representative or by writing Elliott Company, Jeannette, Pa., for a descriptive bulletin.

ELLIOTT Company
STEAM TURBINE DEPARTMENT

H3-11

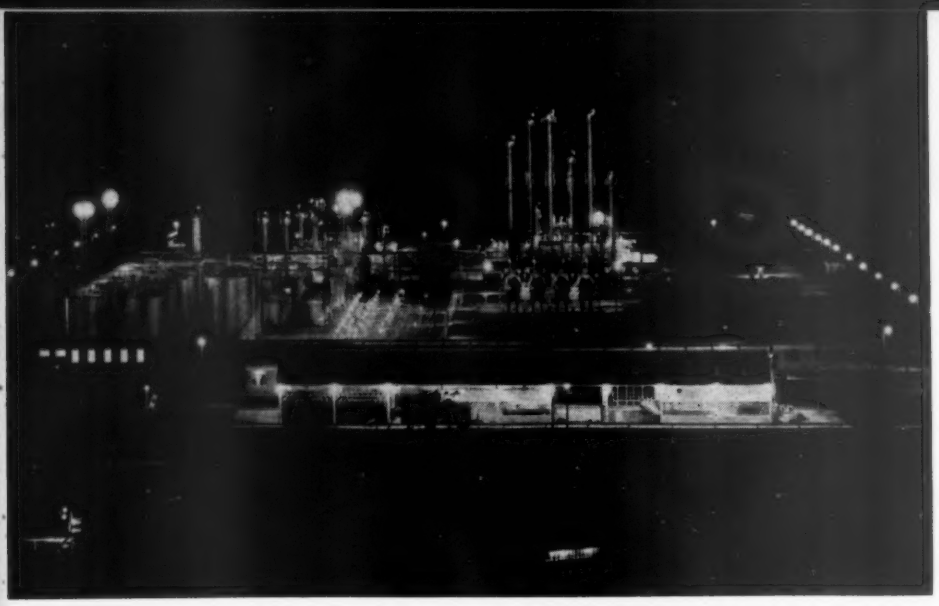


This Elliott 202-hp turbine drives an induced-draft fan through a separate reduction gear, in a midwestern generating station.



An Elliott 250-hp geared multi-stage turbine driving a paper machine. Governor gives close regulation over a wide speed range.

This line of oil pumps is driven by Elliott turbines. This is one of many refinery applications for Elliott turbines.



NIGHT VIEW of Berre (Near Marseilles, France) Shell petrochemical unit for making acetone and other solvents from refinery olefins.

SHELL exhibit at Lyons, France Fair, announcing second French plant for petrochemicals, and products made.

NIGHT VIEW of new "Teepol" plant of Societé Shell-Saint-Gobain, at Petit-Couronne, France, that went on stream recently with 25,000 tons per year rated capacity. This company is owned jointly by Shell and Saint-Gobain, one of France's oldest chemical companies.

eral extraction processes, as with vanilla beans, oranges, lemons, grape fruit and other fruits for flavoring essences. It is also used as a precipitant in the extraction of pectin from citrus fruits, where it is superior to ethyl alcohol, and also in the perfumary and cosmetics industries as an ingredient for perfumes, toilet waters and hair tonics.

Isoproply ether is a valuable solvent in many processes where its lower volatility renders it preferable to ordinary ethyl ether. It is of particular value for low temperature extraction work. It is also used in the textile industry as a delustring agent for acetate rayon.

Although the Berre chemical plant is designed for a flexibility of product distribution, current capacities are 7500 metric tons of acetone and 3000 tons of methyl isobutyl ketone a year. Pipe lines to solvent storage tanks are laid on concrete supports at ground level. Compressors, pumps and other large items of equipment are protected by concrete sheds, while control areas are totally enclosed. The control laboratory has white tile walls and bench tops.

Apart from manufacturing units, the Berre chemical plant entailed the construction of numerous storage tanks, including pumping tanks, tanks for intermediate products and large tanks for finished materials. It also comprises cooling water pumps and a cooling tower, compressors to provide compressed air to the control apparatus and some small tanks to receive sulfuric acid and soda.

Because of the large number of products handled, both crude and finished, and taking into account the consumption of raw materials and chemical products, the storage capacity of the Berre chemical installation is of the order of 6500 cubic meters distributed over 58 tanks. This plant receives its raw materials, etc., by tank trucks and wagons, except, of course, the propane-propylene stream which is obtained direct from the Shell Berre refinery. It ships finished products in tank trucks, wagons or drums.

The installation for packing and filling drums includes a storage space for empties; a washing, de-denting, dry testing, painting and drying unit; equipment for filling with automatic weighbridges and a storage space for full drums. This building is served by a road and two railway lines and includes, moreover, two filling stations, one for tank lorries and the other for tank wagons.

In fine, Shell Saint-Gobain, at their Berre and Petit-Couronne petrochemical plants, employ 230 persons, and have spent 200 million francs for the construction or acquisition of 45 homes for their staff. These two pioneer installations are making products available to the French economy for which the outlets are continually expanding. Operation of the Berre chemical plant is enabling the tonnage of solvents imported into the country from foreign sources to be reduced and is resulting in an annual saving in foreign currency of close on $700,000. ★ ★ ★

FIG. 1. External view of Fluor mobile research laboratory.

Mobile Research Laboratory

How a motor unit is designed, laid out, equipped, and instrumented for petroleum and petrochemical industries

RAYMOND C. BAIRD

The design, construction, and instrumentation of a mobile research laboratory used for making field measurements in acoustics, vibration, and pulsative fluid flow are discussed, with special reference to the instrumentation involved and the range of its capabilities. The effect on design resulting from several years' operating experience with an earlier mobile laboratory is shown. Installations, equipment, and activities with which operation of such a mobile research laboratory may be associated are described and illustrated.

For several years the organization with which the writer is associated has maintained a mobile research laboratory[1] for the purpose of making electronic measurements of a physical nature, principally in the fields of acoustics and vibration. Operation of this unit for considerably more than 100,000 miles throughout most of the United States and in Canada has resulted in a very practical background of knowledge concerning design requirements for a laboratory of this kind. The unit was a modified two-wheeled house trailer which was removed from the manufacturer's assembly line before the furniture and other house trailer equipage had been added. A motor-generator unit was installed together with an instrument console. Oscillographic instruments were included for recording directly electrical signals which were proportional to the static and dynamic physical quantities being measured.

This first mobile unit was used principally in connection with the design and installation of gas pulsation dampeners, which are used for the minimizing of pipe vibration,[2,5] and to investigate other phenomena that may result from compressor (or pump) induced pulsative flow.[3,4] With time, however, the need for making other and more complex measurements increased along with the demand that integration of the basic instruments be accomplished to provide necessary flexibility for the simultaneous measurement of various physical phenomena.

One of the basic requirements for the successful utilization of electronic equipment in the field is that a well stabilized source of electrical power be available. Although in most cases the plants tested could provide power for operating the electronic equipment in the mobile rig, such power was frequently generated in the plant itself and, for this reason, voltage and frequency regulation often left much to be desired. Accordingly, a 3.8 KVA generator was incorporated to provide the much needed stabilized and frequency controlled voltage.

As a result of many miles of travel, coupled with the fact that the house trailer body was not constructed to withstand the loads and road service demands put upon it, the old laboratory naturally became rather road-weary to the degree that it was deemed dangerous with regard to roadability. But, as it had so well demonstrated its usefulness, authorization was granted for the design and construction of a new unit to include even more complete instrumentation to say nothing of the ruggedness which was lacking in the old lab.

The basic functional-use requirements controlling the design of the new mobile research laboratory were postulated to be as follows:

a. Improving products by full scale research under field conditions.

The Author

Raymond C. Baird is principal research engineer in the physical section, The Fluor Corporation, Research and Development Division, and supervises all activities of this section, which are concerned with physical and mechanical enneering. He received his B.A. degree from the University of California at Los Angeles in 1938, after which he obtained a B.S. degree in meteorology and an M.S. in physics at the California Institute of Technology. Military service as a battery officer in the Coast Artillery and, later, as an Air Force meteorological officer during World War II occupied his time until he joined the research and development depatment of The Fluor Corporation early in 1946. During his employment by Fluor he has been actively engaged in research, design and development work in the fields of electronics, gas cleaning, heat exchange, acoustics, and in all phases of the general field of fluid dynamics, with particular emphasis on the study and analysis of problems involving vibration and pulsative flow in both gas and liquid systems. In addition, he presently directs all the acivities of a rather well-equipped mobile laboratory used for the prosecution of field surveys involving the dynamics of fluid systems or mechanical structures.

*Presented at the Pacific Coast Gas Association, Technical Section, Santa Barbara, California, May 13 and 14, 1953, and published here for first time.

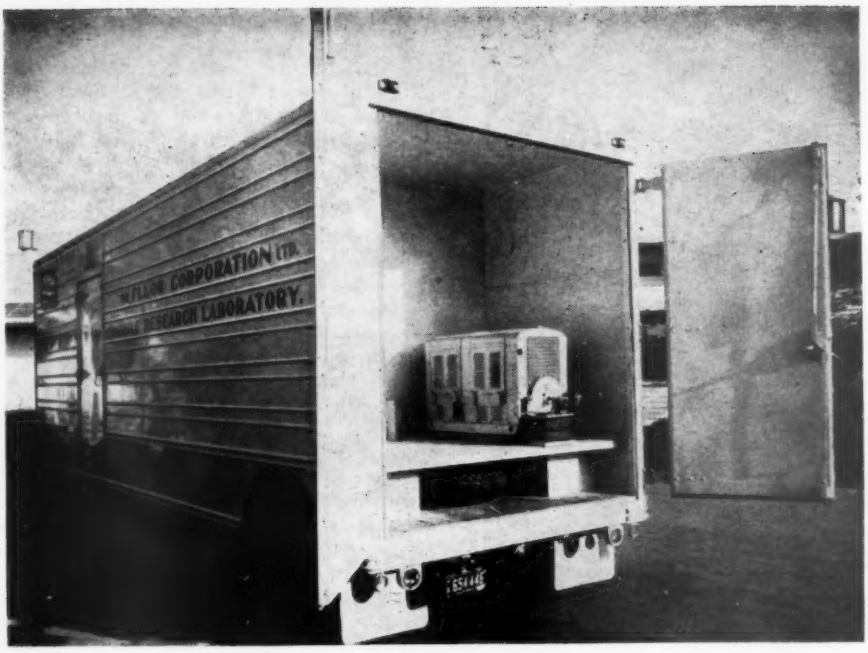


FIG. 2. Laboratory generator unit installed.

b. Determining the feasibility of application of a manufactured product.

c. Substantiating product guarantees.

d. Aiding in the solution of field engineering problems.

e. Conducting field research not connected with product development.

f. Gathering engineering design data for engineering full scale installations.

g. Use as a technical sales adjunct.

To further these requirements the chief objectives in the formulation of the design were: (1) greater instrumentation capabilities; (2) increased operational efficiency; (3) greater general ruggedness and roadability (and incidentally, more physical comfort for the research engineers); and, (4) better appearance.

The external appearance of the completed mobile laboratory is shown by Figs. 1 and 2. The large amount of free working space and indication of the instrument storage capacity are shown in Fig. 3. Fig. 4 shows the rack-and-panel mounted instruments that are within easy reach of the operator from his position behind the operating desk.

The basic floor plan evolved is illustrated in Fig. 5b. For comparison Fig. 5a shows that of the first mobile unit. Functionally, the two plans are quite different aside from the dominating fact that the shell for the first was a standard type house-trailer whereas for the latter it is a custom-built moving van.

The generator, formerly located in the front end of the old unit, has been moved to the rear of the new one. A sound-proofing septum has been incorporated which effectively isolates it from the operating area both thermally and acoustically.

All portable test equipment, pressure transducer stock, electronic testing and trouble-shooting equipment, et cetera, are carried in steel cabinets parallel to a long work bench. The bench itself is designed so that electronic trouble-shooting and repair may, if necessary, be conducted simultaneously with pipe-fitting of a minor nature. All installed instrumentation is rack-and-panel mounted in the forward end of the trailer adjacent to the operator's desk. A refrigerative type cooling system is included with its two Frigidaire units centrally located so as to provide low pressure-drop circulation.

Three different tractors were used in succession to pull the first laboratory and comprised (1), a passenger car with fluid drive which was unsatisfactory in many respects, (2), a three-quarter ton International truck which was all right except for a poor torque curve and, (3), a three-quarter ton Chevrolet truck having a relatively flat torque curve. The last was found to be the most generally satisfactory.

The tractor for the new laboratory is a cab-over-engine 150 hp White truck. It was selected for its power, the fact that it would provide a short overall length for the tractor plus trailer, mechanical maintenance features, and general appearance. It has a four-speed transmission plus overdrive and a two-speed axle. The overall length is important because of its effect on turning radius and, if shipment of the mobile laboratory by rail ever becomes necessary, the smallest size flat car may be used.

The fixed nature of the instruments in the rack-and-panel mounting, coupled with the difficulty sometimes encountered in positioning the mobile laboratory close by test points made the use of a motor-driven cable reel extremely useful. It is not at all unusual to find it necessary to employ a thousand foot (or more) length of cable to reach important test points. Obviously, the operations of taking out and rolling up such a cable would be quite time consuming. Use of a reel, in addition to saving much time, minimizes twisting of the expensive cables and thus prolongs their useful life. Accordingly, a cable reel was installed in the first mobile laboratory which was equipped with a friction-clutch electrical motor drive for take up. This reel was reinstalled in the new laboratory after removing the friction clutch and arranging the resulting direct V-belt drive to provide controllable drive slippage.

Communication between engineers in the laboratory and test points is normally accomplished by the use of FM radio. The apparatus is in the form of "handi-talkie" sets, and with operation on a frequency of 42.98 Mc quite satisfactory communication can be main-

FIG. 3. Forward-looking interior view.

LOW COST...
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TROUBLE-FREE...

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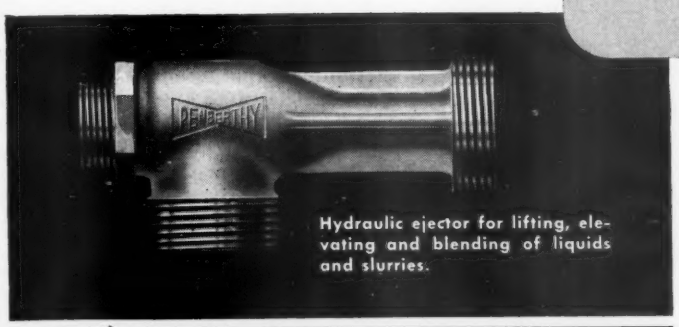
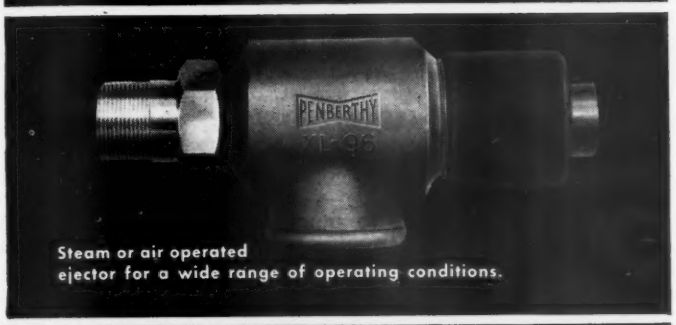
JET PUMPS



Hydraulic ejector for lifting, elevating and blending of liquids and slurries.



Steam or air operated ejector for a wide range of operating conditions.

Submerged type (open suction) for use in tank—has minimum resistance to flow.

Special jet pump for handling corrosive chemicals.

Consider the simplicity of the jet pump. It uses steam, water, air or gas under pressure to transfer or mix, without clogging, *any liquid which will flow through pipes.* It has no moving parts or packing glands. Needs no lubrication or maintenance. It's practically noiseless, costs little and is compact.

Penberthy makes a full range of jet pumps. They are being used in standard and unusual applications. Where necessary, they are made to withstand corrosion, contamination and high temperatures.

Penberthy, from wide experience, can help you save time and money, increase the efficiency of your operation. Take the first step by writing for Bulletin No. 512 which details the complete line of jet pumps by Penberthy.

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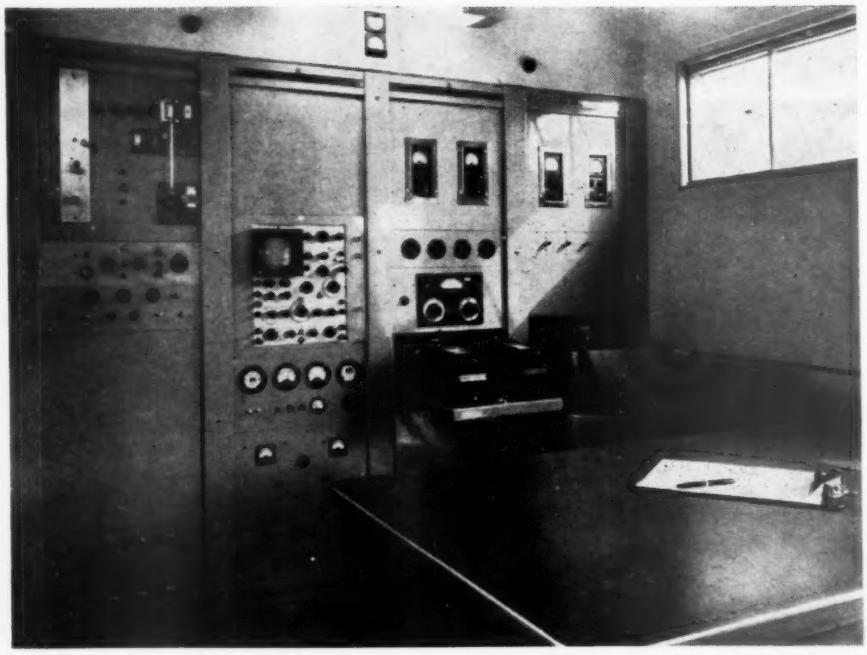

FIG. 4. A very compact instrument rack.

tained even through steel reinforced walls such as are found in compressor buildings. No particular difficulty has been experienced for short distance communication in refineries and the like in spite of their maze of piping and steel structures. All in all, the relatively high initial cost of such communication equipment is very little as compared with the saving in time which would otherwise be expended in the stringing and relocating of telephone lines. The instrumentation cables themselves may be used as communication lines, however, considerable loss of flexibility and increased likelihood of interference with data collection.

From time to time it may be necessary to obtain synoptic data from widely separated points. Such a requirement may come about for example, during pressure surge experiments on long pipe lines. To answer this need, base and mobile FM radio stations operating on a frequency of either 49.58 Mc or 49.70 Mc can be employed either for the simultaneous gathering of data or for the transmission of synchronizing pulses from the mobile laboratory to as many as five widely dispersed points. The use of radio communication in this way may be thought of as providing instrumentation cables having virtually any desired length as compared to the finite sized cables carried on the power-driven takeup reel used for routine in-plant instrumentation.

The instruments installed in the new mobile research laboratory have approximately twice the utility of those which were available in the old one. Four oscillographic recording channels are now available where, previously, there were but two. With these channels simultaneously recording of pulse, vibration, and/or acoustical phenomena may be taken.

The four main amplifiers normally used to actuate the recording oscillographs are standard Brush Type BL-905 units and are mounted without physical modification in the upper sections of the two right-hand equipment racks appearing in Fig. 4. All pre-amplifiers, main amplifiers, carrier amplifiers, and oscillographs are mounted in a manner which permits easy removal for portable use. If it becomes necessary to perform a survey with a minimum of delay, the necessary equipment may accordingly be removed from the racks and flown to the job site.

Centrally located within easy reach of the operator, and at desk height, are two direct inking brush magnetic Type BL-202 oscillographs, each having two channels plus a pip marker. These are mounted on slides which retract into the equipment rack when not in use. The oscillographs have a useful frequency range extending from 0 to 120 cps. Operation of the two oscillographs may be synchronized by pipper-pen marks along the edge of each graph.

Function-switching dials and the amplifier calibration voltage control panel are at eye level to minimize parallax errors. An oscillograph switching arrangement makes it possible to connect any oscillographic channel to the output of any one of the four main amplifiers, carrier amplifiers, or to the electronic horsepower measuring equipment. Two or more of the oscillographs may be connected simultaneously to any circuit, enabling a quick check of the functioning of an oscillograph to be made on a comparison basis. The amplifier switching panel makes it possible to change connections of each of the main amplifier input terminals from the transducer output to the pre-amplifier output, or to the calibration-voltage source.

The lower sections of the two right-hand equipment racks (Fig. 4) contain four pre-amplifying electronic integrators. The use of such units is mandatory since additional amplification of the transducer output signal at low pulse amplitudes (i.e., below 0.7 psi) is often necessary. Additionally, integration of the signal voltage produced by magnostrictive type transducers used in pulse pressure measurement is required because this voltage is proportional to rate of change of the pulse pressure and not to the pressure itself.

Mounted on retractable slides above the pre-amplifiers in the right-hand equipment rack, are two amplifiers of the carrier type (Brush Universal Analyzer Model BL-320). This type of amplifier is used whenever it is desired to record electric signals corresponding to static plus dynamically variable quantities as may be present, for example, in the instantaneous pressure drop across an orifice plate, a vessel, or a section of pipe line, due to the effect of pulsative gas flow.

The input to the carrier amplifier is formed by a balanced-bridge type circuit which is usually formed by strain gage elements. Unbonded strain gages permanently included in pressure and

TABLE 1. Physical measurement capabilities of Fluor mobile research laboratory.

Ranges indicated represent those that can be covered using standard equipment and methods of equipment integration. It is possible to extend some of these to meet unusual demands.

A. Acoustical measurement ranges.

Frequency				
Level measurements only	Frequency analysis	Intensity	Pressure	Temperature
0–1200 cps	0–1200 cps	24 to >140 decibels	Atmospheric	−60 F to 250 F
1200–10,000 cps	1200–7500 cps		Atmospheric	<32 F to 120 F

B. Vibration measurement ranges.

	Frequency analysis	Intensity level	Temperature
1. Acceleration	2–2500 cps	0.16″/sec² to 3900″/sec²: (rms)	<32 F to >120 F
2. Velocity	2–2500 cps	160 x 10^{-6}″/sec to 300″/sec: (rms)	<32 F to >120 F
3. Displacement	0.17–7500 cps*	16 x 10^{-6} in. to 30 in.: (rms)	<32 F to >120 F
	0–120 cps†	<16 x 10^{-6} in. to >30 in.: (rms)	−60 F to 500 F
	2–7500 cps‡		

* Portion < 2 cps analyzed on oscilloscope through pre-amp.
† Analysis from oscillographic recording.
‡ Analysis by wave filter.

C. Pulsation measurement ranges.

Frequency	
Ranges	0 to 5000 cps
Analysis	0 to 5000 cps
Intensity level	<10^{-3} per cent* to ≅ static pressure
Temperature	−60 F to 350 F

* Based on a 500 psi static pressure.

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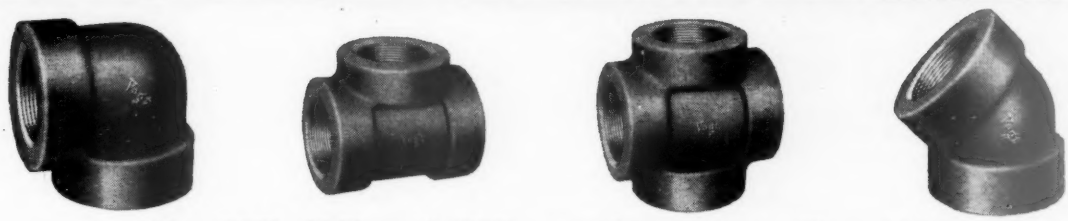

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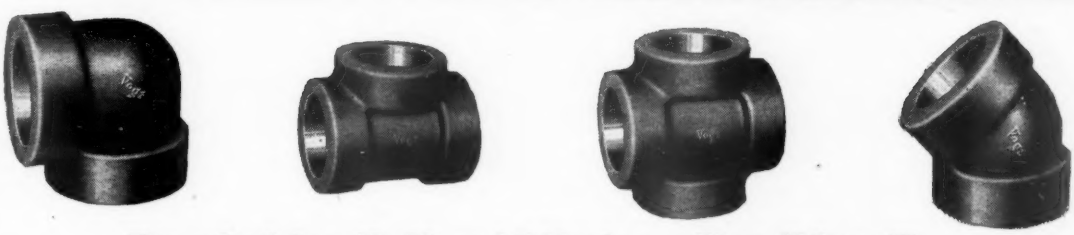

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differential pressure transducers are normally used in field measurements. For vibration and stress studies the strain gages themselves are normally cemented to the structure being tested.

As shown in Fig. 5b, a dynamic pressure transducer calibrator is located along the left wall of the trailer between the clothing locker and portable equipment storage cabinet. This device makes it possible to calibrate or verify the calibration of dynamic type pressure transducers while in the field. Heretofore, if such transducers were dropped or struck accidentally, it was necessary to discontinue using them until they could be checked at the home office. The dynamic pressure transducer calibrator was designed and constructed specifically for inclusion in the new mobile research laboratory and is a unique instrument in itself. Sinusoidal pressure variations are mechanically generated in a hydraulic system, the drive for which comes from a 1750 rpm electric motor coupled through a continuously variable speed unit and three-step pulley arrangement to the dynamic pressure generating member. The speed range covered by this apparatus provides for the production of sinusoidal pulse pressures at any frequency between 0.67 and 25 cps. Pulse amplitudes between 0 and 50 psi may be generated

TABLE 2. Installations, equipment, and activities with which operation of the mobile research laboratory is involved and the types of measurements normally made (using electronic equipment).

a. Refer to Fig. 6.

Illustration	Installation, equipment, or activity	Types of measurement					
		Acoustical	Vibrational	Pulsative	Stress*	Horsepower	Pressure loss**
A	Pumps		X	X		X	
B	Heat exchangers		X	X			X
C	Mufflers	X	X				X
D	Operating end of mobile research laboratory	..	..	..	..	..	..
E	Engine intake cleaners and silencers	X	X	X			X
F	Pulsation dampeners		X	X			X
G	Compressors		X		X	X	
H	Pulsation dampener systems		X	X	X		X
I	Plant piping		X	X	X		X
J	Orifice metering			X			X

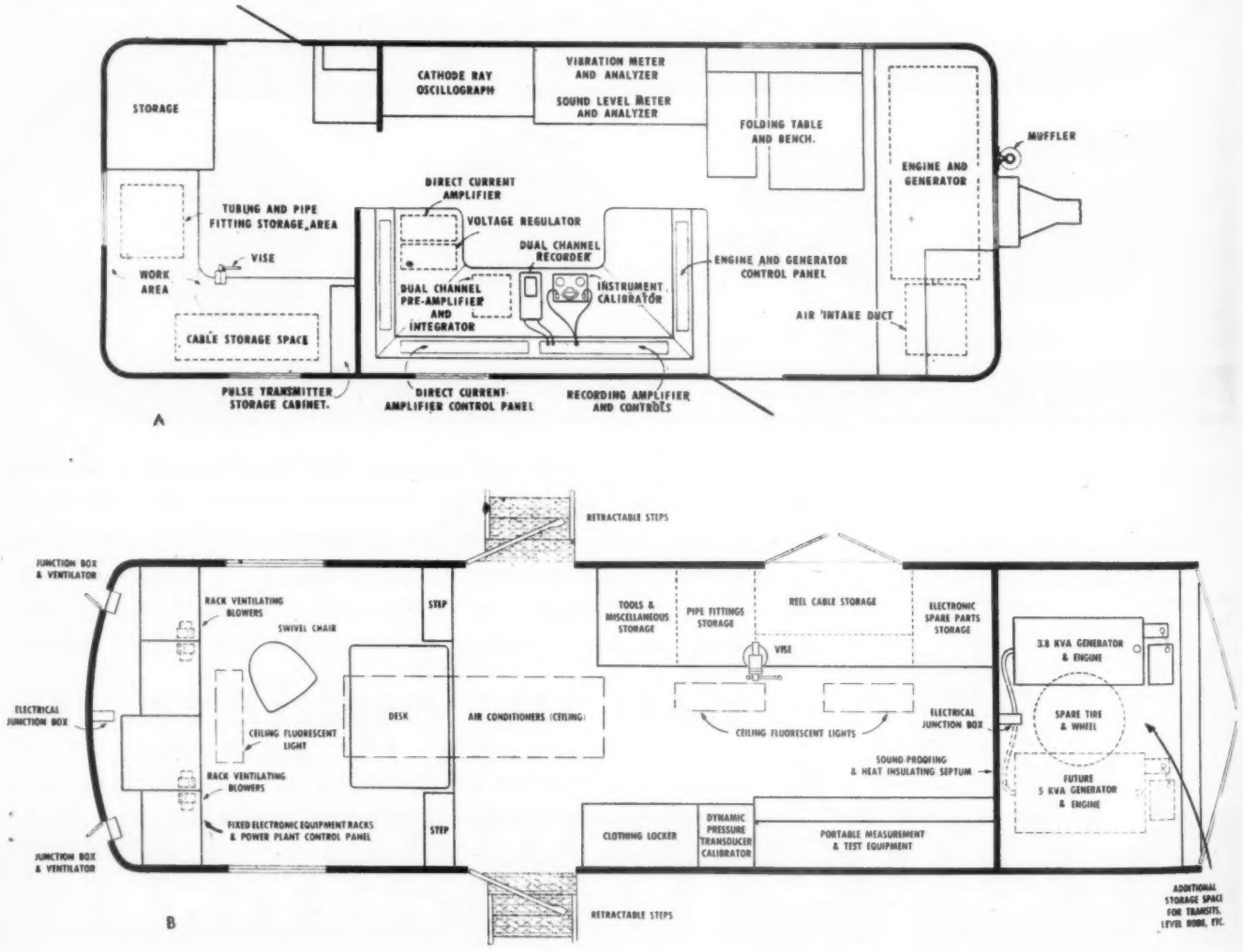
* Dynamic and/or static.
** Average and/or instantaneous.

b. Refer to fig. 7.

Illustration	Installation, equipment, or activity	Types of measurement					
		Acoustical	Vibrational	Pulsative	Stress*	Pressure loss**	Recycling
A	Turbo-generators	X	X				
B	Contacting columns		X		X		
C	Atmospheric heat exchangers	X	X	X			X
D	Trouble shooting and repair end of mobile research laboratory	..	..	..	..	..	..
E	Blow-off silencers	X	X				
F	Heavy construction				X		
G	Cooling towers	X	X	X			X
H	Gas cleaners					X	
I	Fans	X	X		X		
J	Gas holders		X	X			

* Dynamic and/or static.
** Average and/or instantaneous.

FIG. 5. Floor plan of first research laboratory (A), and (B) floor plan of present mobile laboratory.



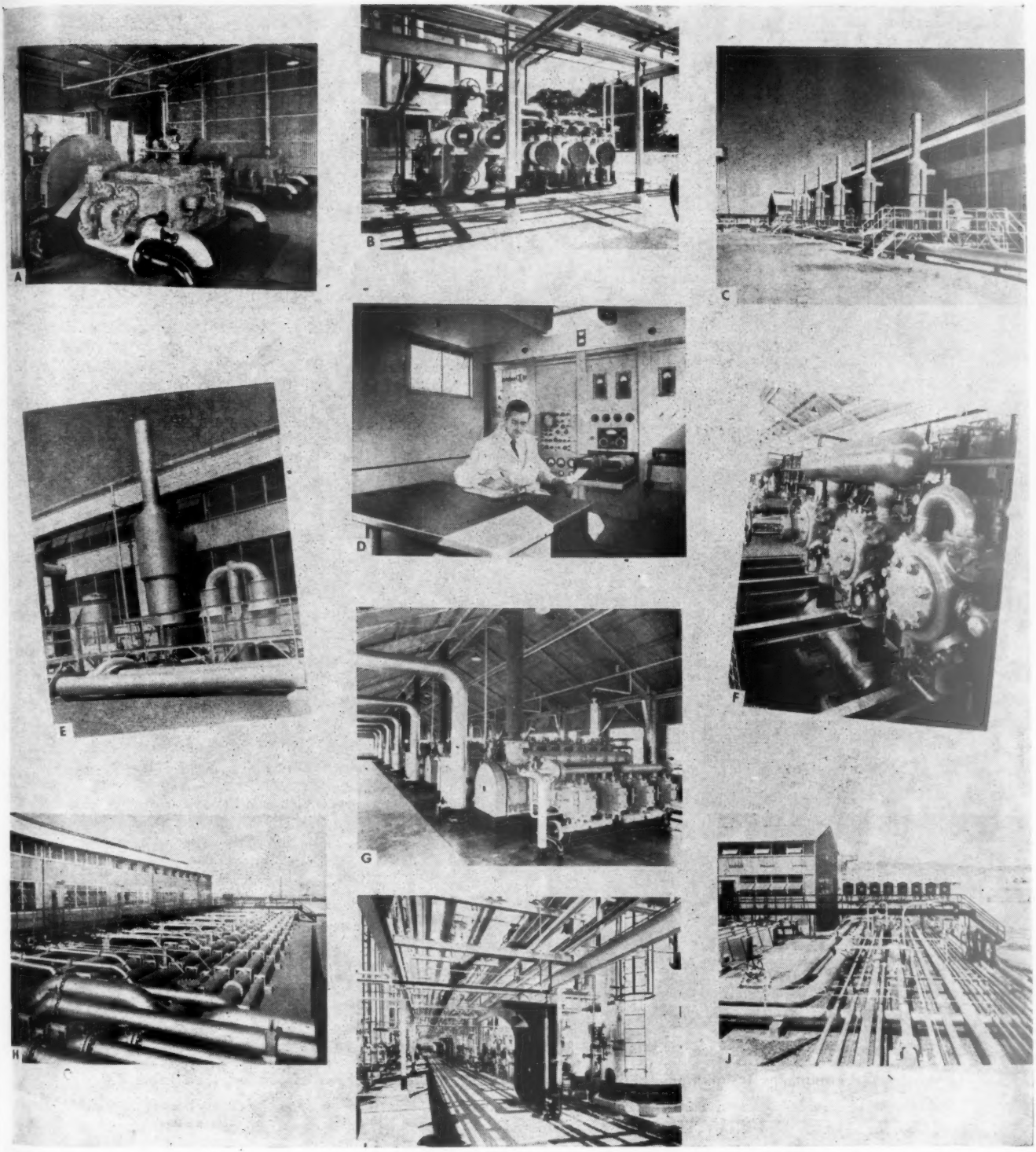


FIG. 6. Assembly views of installations, equipment, and activities with which the laboratory is associated. (See Table 2.)

anywhere within this frequency range, the upper limit depending somewhat upon the static pressure. Static pressure is produced by means of a hydraulic pump capable of pressures up to 5000 psi. Actual dynamic pressure transducer calibration is made by comparison of the wave amplitudes recorded simultaneously from the magnostrictive (or crystal type) transducer with those of an unbonded strain gage transducer, both transducers being coupled to the pulsing hydraulic system. The strain gage type transducer is calibrated statically by a dead weight tester.

A more fundamental calibration for dynamic pressure transducers may be had, however, by using a balanced pressure switch of the type employed with horsepower balanced-pressure indicators. This device makes it possible to measure the total dynamic pressure excursion with great accuracy. The switch will operate on a differential pressure of a few inches of water at static pressures of more than 1000 psi. Further, wave shape fidelity of a pulse wave from a dynamic pressure transducer (through integrator, amplifier, and appearing on the oscillograph) may be checked by using a balanced pressure switch in conjunction with the electrical horsepower indicator described below.

The two equipment racks on the left side house the power plant operating controls, a-c voltage regulator, electronic horsepower measuring equipment, and a time-base shifting apparatus. An x-y function plotter is scheduled to be installed in these racks at a later date.

From a graph known as a horsepower curve, engine or compressor efficiency can be determined along with some of the reasons for poor efficiency. The horsepower curve is a plot of cylinder

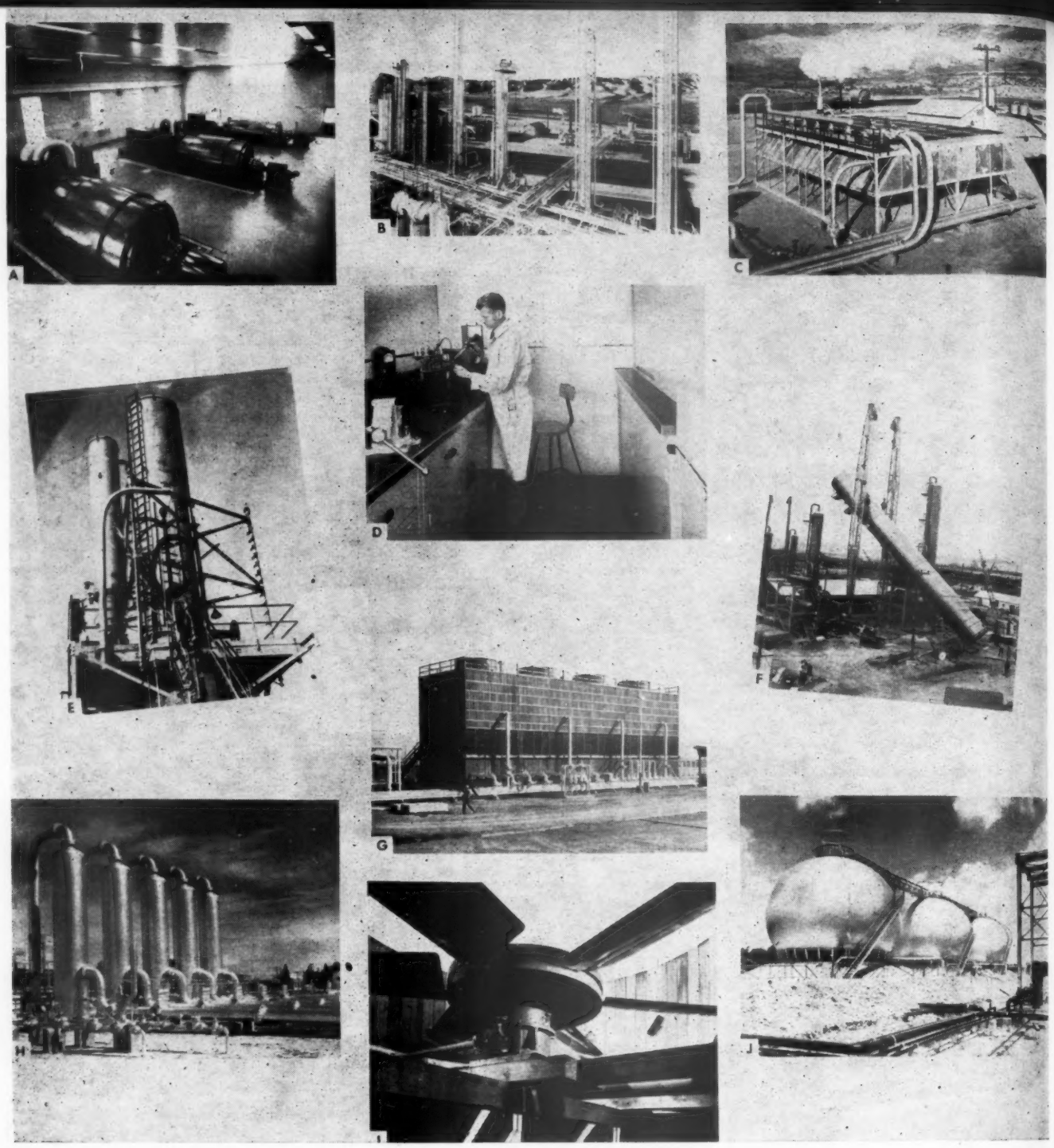


FIG. 7. Other items of equipment, installations, and activities with which the laboratory is associated. (See Table 2.)

pressure versus piston position. There are a number of means available for obtaining horsepower curves ranging all the way from mechanical to electronic. All of these systems have their particular advantages and drawbacks which will not be discussed in this paper except to say that generally the effect of inertia limits the use of mechanical systems to application on low speed pumps and compressors.

The laboratory utilizes two separate systems to plot curves of pressure versus piston position.

One system involves a strain gage type pressure transducer coupled to a a high gain direct current amplifier, thus determining the vertical positioning of an electron beam in a cathode ray oscilloscope. The horizontal position of the beam is determined by a mechanical electro-resistance type resolver, the electrical resistance of the resolver being proportional to the piston position. For calculations and records, a photograph is taken of the cathode ray tube screen.

The second system utilizes the same pressure transducer and piston position resolver as the first. Data, however, are not visually presented on a "scope" screen, but are recorded on a high speed magnetic tape. After recording, the tape is "played back" at less than a hundredth of the recording speed. The slow-speed play-back signals are used to actuate the recorder pen and the chart drive of an x-y function plotter, the pen moving in response to the piston-position signal and the chart drive in response to the cylinder-pressure signal.

Portable instruments for acoustics and vibration measurements with regard to both level and frequency analyses are carried in the portable measurement and test equipment cabinet. They comprise principally General Radio units, which are generally recognized as standard test equipment for such fields of measurement.

The output of these portable instruments are frequently connected through cables to the rack-installed oscillographs to aid in the analysis of pulsative flow problems involving vibration and acoustics.

The range of measurement capabili-

ties for the mobile research laboratory are presented by means of Table 1. Measurements throughout the ranges indicated may require the use of several instruments having overlapping ranges.

Figs. 6 and 7, together with Table 2, illustrate typical installations, equipment, and activities with which operation of the mobile research laboratory is associated. Measurement of various physical quantities for a particular installation may be very simple, or it may be complicated to the extent of requiring simultaneous recordings on several channels, all depending upon the complexity of the problem. In addition to the operations indicated by Figs. 6 and 7, versatility of the mobile research laboratory lends itself to use in unusual types of engineering problems at a moment's notice without the necessity of modifying the installed instrumentation. A sufficient stock of electronic components is carried so that, if necessary, minor modifications can be made in existing electronic equipment and special electronic circuits can be constructed while on the job to make possible the measurement and/or recording of unusual physical quantities.

In summary, a truly mobile research laboratory has been designed and constructed based upon several years of experience with another similar unit, which is rugged and versatile and which can be used to measure and record practically any physical quantity encountered in the petroleum and petrochemical industries. It may be operated under severe climatic conditions and is self-sustaining from the standpoint of trouble shooting and repair of the electronic instruments it incorporates. The feasibility of an organization, such as that represented by the writer, in maintaining a mobile research laboratory has been demonstrated over a period of several years during which time its utility has been justified on an economic basis.

Acknowledgment

The interest expressed by members of the Fluor research staff in reviewing the manuscript and criticizing its scope and contents is appreciated. Particular acknowledgement is due to R. C. Sollars, who participated in the design of the mobile research laboratory and spearheaded its construction, for his assistance in preparing portions of the descriptive material and in tabular presentation of the measurement capabilities of the laboratory.

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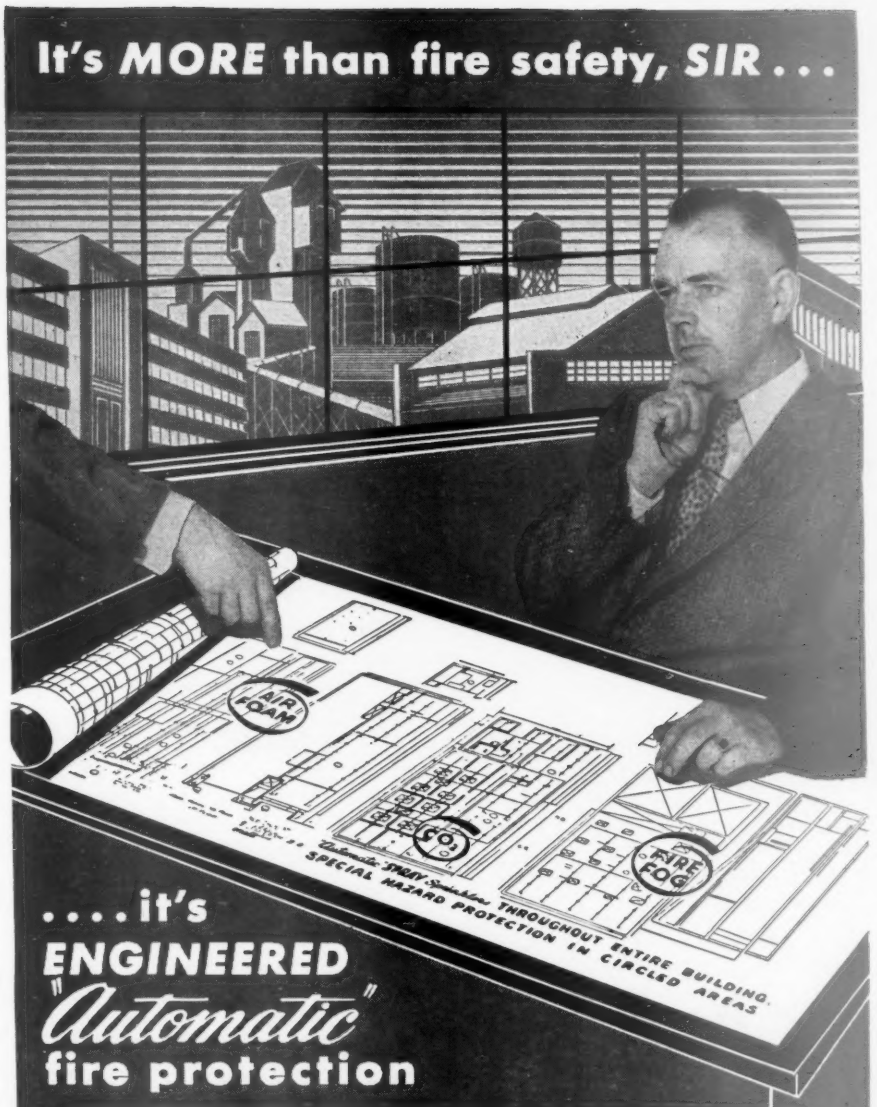

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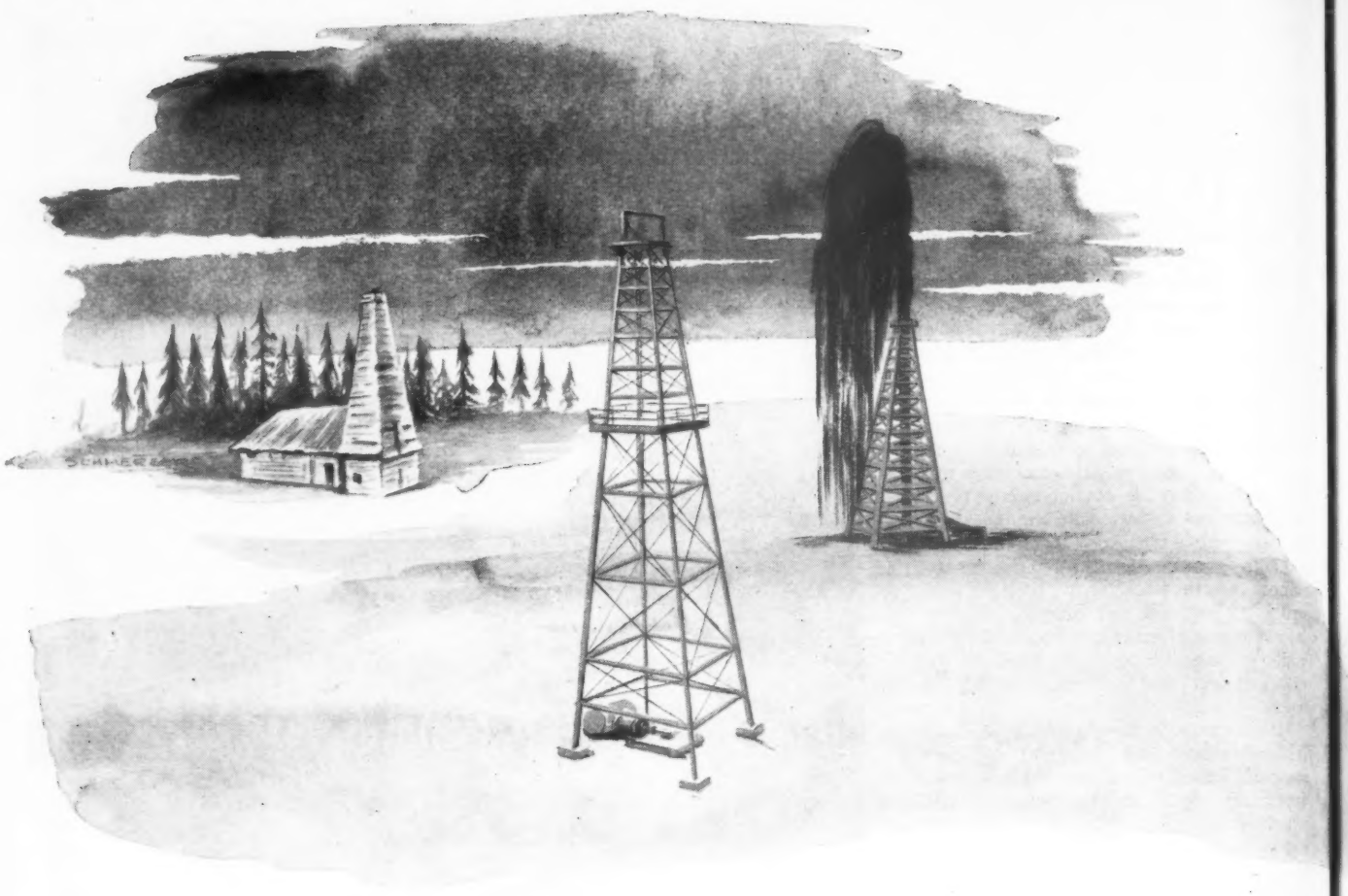

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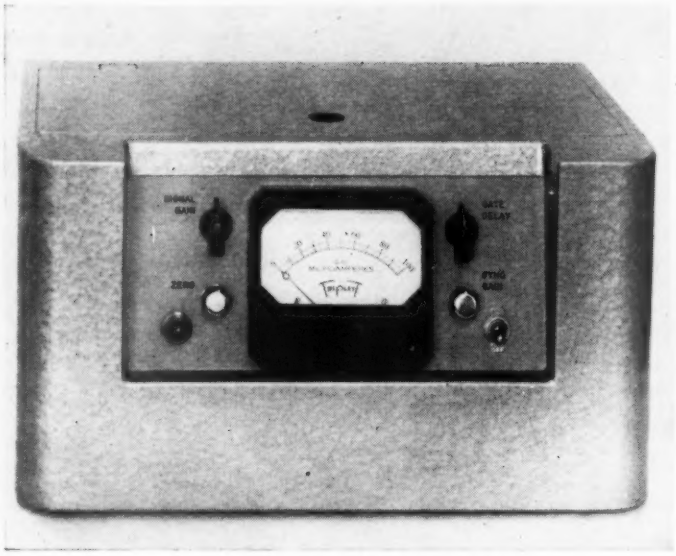

FIG. 1. Front view of knockmeter pilot model.

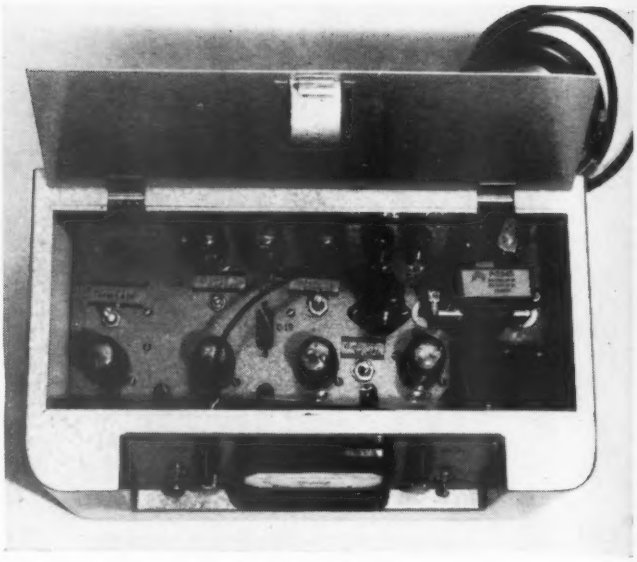

FIG. 2. Inside view of the pilot model.

Electronic Gating Knockmeter Promotes Combustion Studies in Full-Scale Engines

M. M. ADAMS

A CONSIDERABLE number of electronic instruments, which are capable of giving accurate qualitative and quantitative information regarding combustion and detonation in engines, have been developed over the past several years. Limitations, however, exist as to the type of engine with which these instruments can be successfully used, with the transducer that can be employed, with the number of cylinders of the engine, and with the revolutions per minute of the engine. One most important limitation which the aforementioned instruments have in common is an inability to allow the operator to determine the crank shaft angle at which an event of interest is occurring.

Design

The Electronic Gating Knockmeter has been designed with the objective of overcoming the limitations inherent in those instruments already available for use in detonation studies. Figs. 1, 2, and 3 show various views of the pilot model of this instrument, and Fig. 5 is a schematic wiring diagram. The degree of flexibility incorporated in the design of the instrument permits studies in time interval and phase measurements, as well as amplitudes of the signals of interest. Input signal can be derived from transducers as widely different as an inturnal type velocity pickup, an external type velocity pickup, a catenary type pressure pickup, an ordinary crystal microphone, and an ionization gap. Signals that are not of interest are effectively commuted out of observation and measurement through use of a pedestal or "gate" upon which is superimposed the signal which the operator wishes to observe. This gate can be varied from approximately .0002 sec to .020 sec in time length and can be made to occur at any desired phase with respect to engine crank shaft angle through the use of a control on the front panel. This fact permits an operator to select, observe, and measure the amplitude of detonation or combustion in any particular cylinder of a multi-cylinder engine without interference from other cylinders or from extraneous noises normally associated with full-scale engine operation.

A built-in calibration circuit provides a convenient and rapid means of measuring the time width of the gated interval so that a correlation of the distance in engine degrees between occurrences of certain signals can be made.

Operation

The Electronic Gating Knockmeter can be conveniently divided into three channels for operational analysis. The channels are the synchronization channel, the signal and calibration channel, and the integrating channel. A brief description of the functioning of each channel is outlined by reference to Figs. 5 and 6.

A magnetic type pickup is mounted adjacent to the flywheel or some rotating assembly so that during each revolution of the engine the stud moves in close proximity to the magnetic pickup, inducing a voltage pulse in the pickup coil. This pulse is utilized for synchronization of the knockmeter with engine rotation and is transmitted through a cable to the "Sync. Input" jack (Fig. 3). The signal is amplified through a three-stage variable gain, resistance-couple amplifier, composed of the second section of V-5 and both sections of V-1. V-2 is an Eccles-Jordan binary circuit, the function of which is to divide the synchronization pulses by a factor of 2. The input signal from plate 2 of V-1 is a negative pulse with a minimum value of approximately 25 volts; this pulse cuts off the conducting section of V-2 which in turn drives the non-conducting section into operation. The next pulse arriving from V-1 returns the binary stage to its original mode of operation.

A selected portion of the sharp rise in voltage occurring at plate 2 of V-2 is differentiated and used to trigger V-3. The magnitude of this triggering volt-

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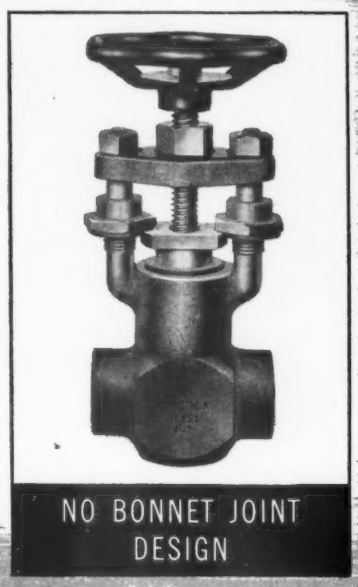

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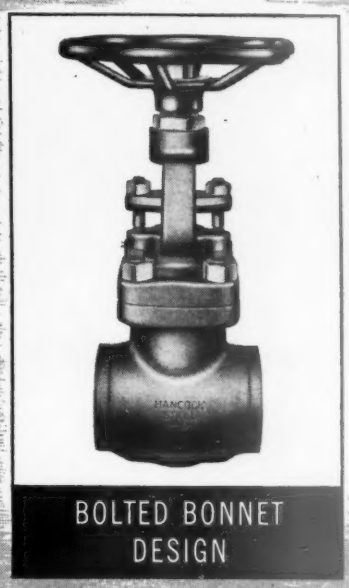

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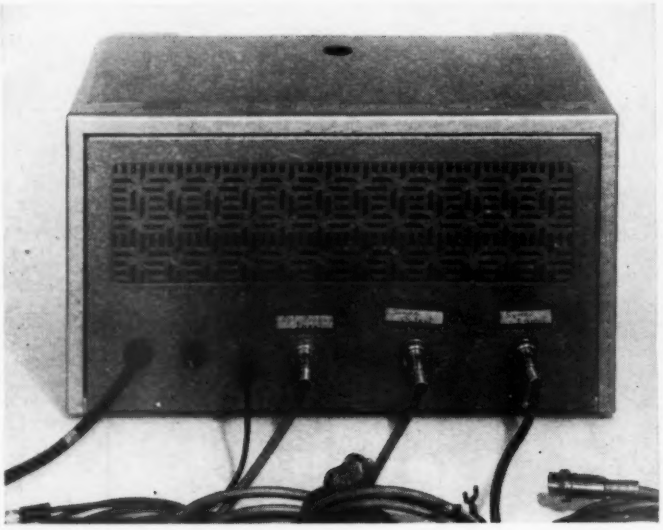

FIG. 3. Rear view of the pilot model, showing electrical connections.

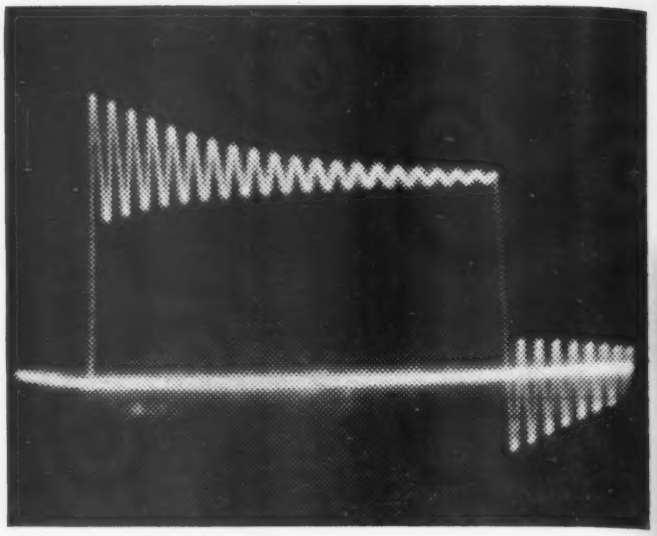

FIG. 4. Typical photo of the oscilloscope trace where the "Cal-Run" switch is in Cal position.

age is not critical but must be of the order of 20 v minimum. V-3 is a one-shot multivibrator with section 1 normally cut off and section 2 normally conducting. When the differentiated, positive pulse from V-2 drives the grid of section 1 of V-3 to conduction, the negative pulse on plate 1 is used to drive section 2 far below cutoff. The time during which section 2 remains cut off can be controlled by the "Gate Delay" control available on the front panel. The delay period can be made as long as .125 sec which corresponds to a complete revolution of an engine operating at approximately 500 rpm. Following the delay period, the second section of V-3 again conducts and section 1 is cut off. When section 1 is cut off, a portion of the positive plate pulse is selected, differentiated, and used to trigger V-4. Again, the magnitude of the trigger voltage is not critical but must be a minimum of about 25 v. The magnitude is determined by the setting of the "Delay Output" potentiometer available through the cabinet top. At the instant of initial triggering of V-3, plate 2 rises in voltage. This positive pulse is used to trigger the external sweep of the oscilloscope used with the equipment and is available at a jack on the rear of the instrument (Fig. 3).

The differentiated positive pulse imposed on the grid of section 1 of V-4 drives that portion of the tube to conduction and the second section, which is normally conducting, to cutoff, producing a negative pulse on plate 1 and a positive pulse on plate 2. Both pulses have a magnitude of approximately 90 volts and the time length is determined by the setting of the "Gate Width" control available through the top of the instrument. The "Gate Width" control allows selection of any gate width by the operator between the values of .0002 sec and .020 sec.

In summary, the function of the synchronization channel can be described as (1) reducing by a factor of 2 the number of synchronization pulses from the flywheel pickup, (2) introducing a selected delay period following each remaining synchronization pulse, and (3) generating a gate of selected width following completion of the aforementioned delay.

The signal and calibration channel is comprised of section 1 of V-5 and section 2 of V-6. These two triodes form a variable gain, high input impedence amplifier. The first section of V-6 (the output stage of the amplifier) has its plate tied directly to plate 2 of V-4 (gate generator) through a 220,000-ohm load resistor. The available plate supply voltage is approximately 95 volts, except during the gating period when it abruptly rises to, and remains at, 185 v. This produces the rectangular DC pedestal upon which signals arriving through the "Pickup Input" jack are superimposed. Maximum gain of the amplifier is approximately 60 db and the frequency response is flat to 5 kilocycles. A lead from the plate of the pulsed stage is taken directly to the "Scope Output" jack on the rear of the instrument so that it can be impressed on the vertical plates of an oscilloscope for observation. The same signal is impressed on a high impedence voltage dropping circuit which transmits it to the integrating channel.

The calibration section consists of a high Q, 50-millihenry choke in parallel with sufficient capacitance to resonate the circuit at 5 kilocycles. When the "Cal-Run" switch inside the cover is turned to the Cal. position, this parallel resonant circuit is placed between the grid resistor and ground of the pulse stage. When the gate pulse occurs, the leading edge drives the circuit of the "ringing" oscillator through capacitative coupling and these decaying oscillations are impressed on the grid circuit and may be plainly seen on the oscilloscope screen. Since this circuit is tuned to 5 kilocycles, each cycle of the ringing circuit corresponds to a time interval of .2 millisecond. A typical photograph of the oscilloscope trace when this switch is in the Cal. position is shown in Fig. 4.

The integrating channel is composed of both stages of V-7 and associated circuity. Section 1 of V-7 is normally held far below cutoff until the gate pulse is registered in the signal output. This high amplitude pedestal with the superimposed AC signal upon it drives section 1 of V-7 as a pulsed cathode follower. The peak voltages are averaged in a long time constant circuit, and this average voltage is applied to the second section of V-7 to drive the meter movement from the cathode circuit. The meter is a 4½-in., 0 to 100-microamp instrument and has an additional 20,000 ohms placed in series with it to prevent damage in case of sudden voltage surges. The "Threshold" control, available inside the cabinet, offers a means of changing sensitivity of the instrument when used in conjunction with the

The Author

A native Sooner, M. M. Adams went to college at Oklahoma A. & M., and later graduated from Brooklyn (New York) Polytechnic Institute, with a BEE degree, majoring in electronics. During the period of "the lean '30's" he performed a multiplicity of duties with Carter Oil Company and other oil outfits. Into the U. S. Marine Corps in 1942 early in World War II he served in the South Pacific and later as instructor and technician in radar. When Bendix Aviation Company undertook a research program in guided missles, Adams worked on that job until 1948, when he joined the Instruments Division of Phillips Petroleum Company. For the last two years he has been manager of this group, a position he now occupies.

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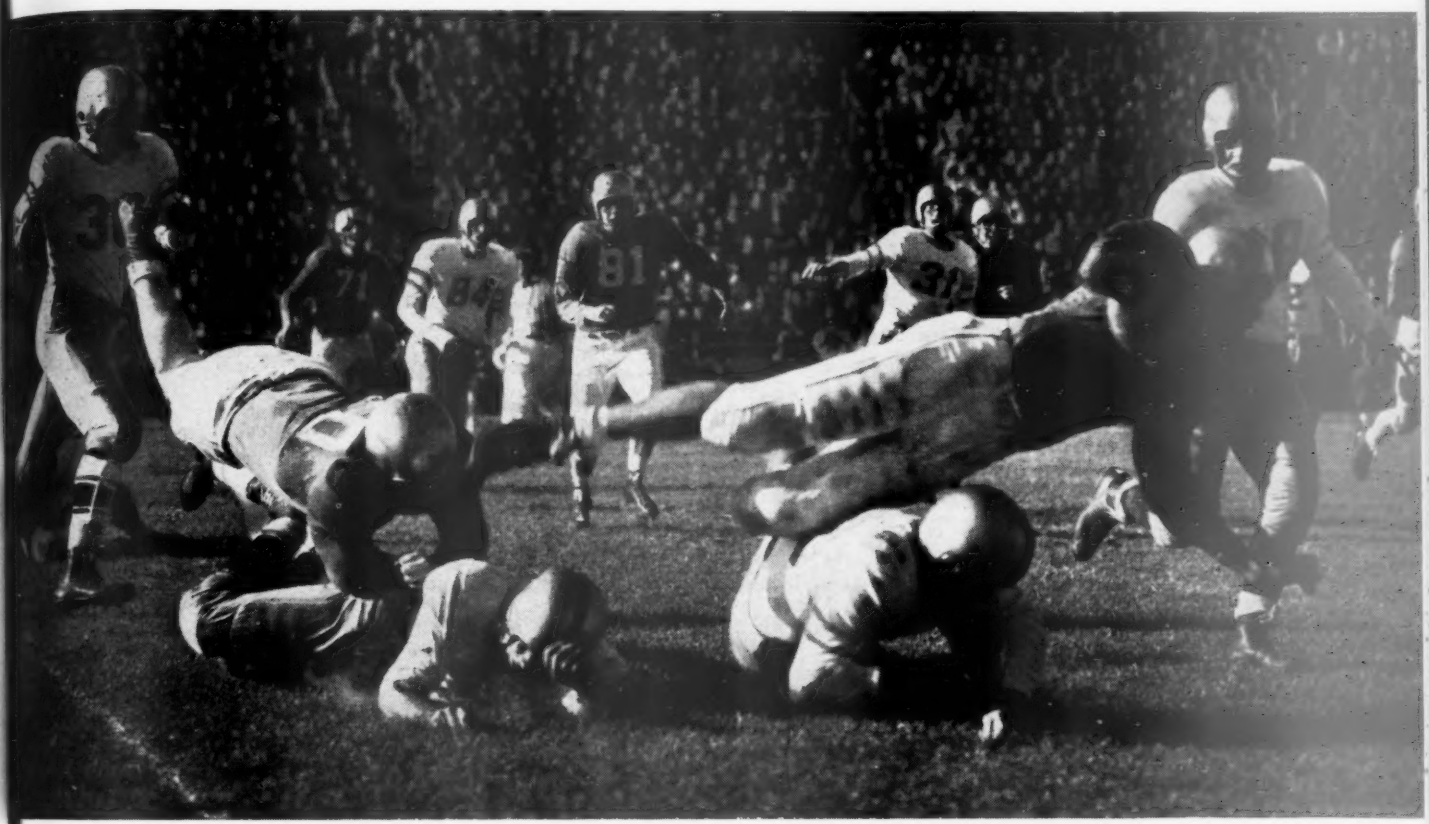
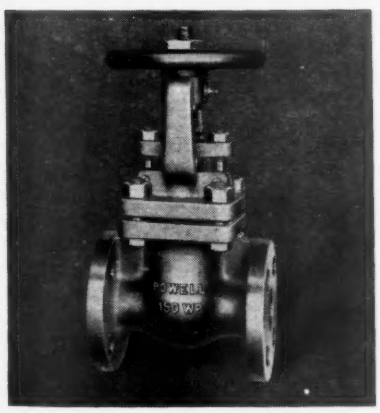


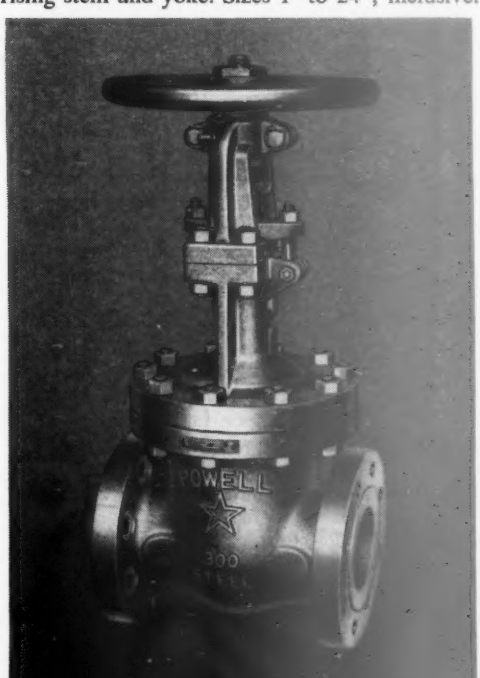


O.S. & Y. GATE VALVE *(Fig. 2491)* for 150 pounds W.P. at 500 F. Stem is threaded and guided through a revolving bushing in upper yoke. Sizes ¼" to 2", inclusive.

CAST STEEL SWING CHECK VALVE *(Fig. 1561)* for 150 pounds W.S.P. Bolted flanged cap. Heavy rugged construction. Available in sizes ¾" to 18", inclusive.

BRONZE "WHITE STAR" GATE VALVE *(Fig. 375)* for 200 pounds W.S.P. Union bonnet with inside screw rising stem. Renewable "Powellium" Nickel-Bronze wedge.

CAST STEEL GATE VALVE *(Fig. 3003)* for 300 pounds W.S.P. Bolted flanged bonnet with outside screw, rising stem and yoke. Sizes 1" to 24", inclusive.



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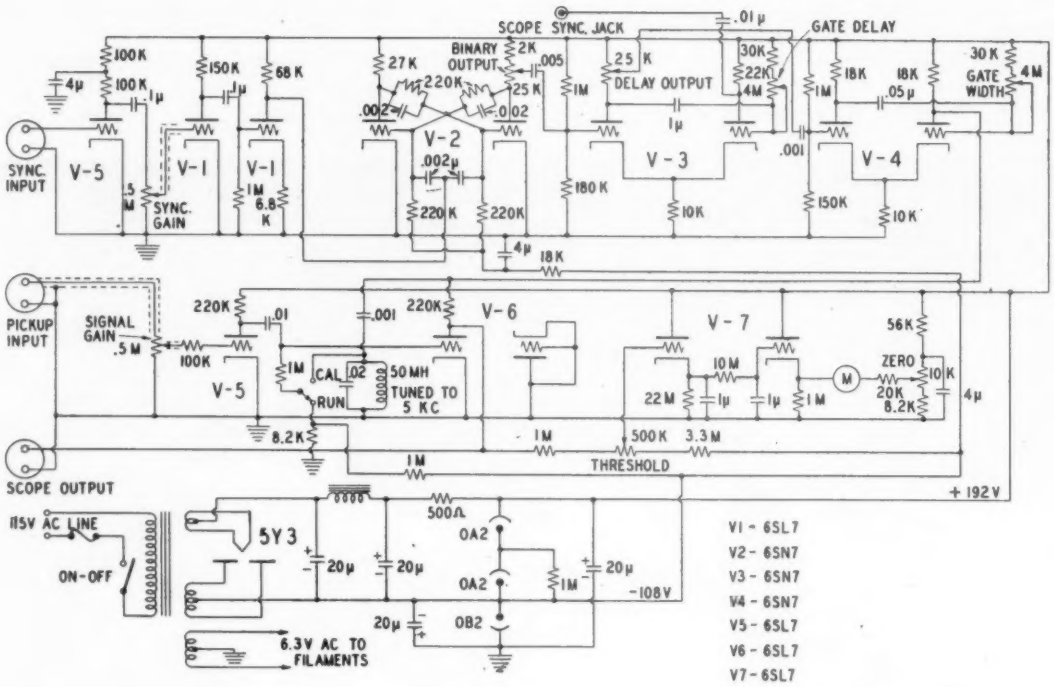

FIG. 5. Schematic diagram of electronic gating knockmeter.

"Zero" control, available on the front panel. In cases where extreme sensitivity is required, the instrument may be operated at a depressed zero to overcome certain limitations. Linearity of this integrating arrangement has been checked by a plot of input signal versus meter readings and found to be highly satisfactory.

Specialized Uses

In addition to utilizing this instrument in routine automotive testing, limited experience has indicated that other research programs can be greatly aided by utilization of this device. Several of the experiments made possible through use of this instrument are described below.

1. Using a crystal microphone as a transducer and gating on the audible signal emanating from the crank case door on a Research Method engine, a plot of constant, audible knock intensity versus micrometer settings was made from the 80-octane level to the 148-performance level. Tests were conducted on two different engines with results, in both cases, in almost perfect coincidence with the high octane reproducibility study group guide curve. From time to time during these tests, in an effort to determine if the microphone had slipped from its original position, attempts were made to reproduce micrometer settings using the level indicated on the Electronic Gating Knockmeter scale. Using only this indication it was possible to "blindly" return the micrometer readings to within .003 in. of the original setting. Spread used during this test was approximately twelve divisions per octane number at the 90-octane level.

2. During work connected with sound wave observations, it was observed that the output of an internal type pickup varied in an erratic manner with respect to crank shaft angle when auto-ignition or pre-ignition was occurring. In this test, the gate width was set to represent about five degrees of crank shaft rotation and the peak output of the D-1 pickup superimposed on the gate center. Pre-ignition and auto-ignition manifest themselves by erratic and immediately obvious movements toward the leading edge of the gate. Ordinary dp/dt pickup phase eccentricities from cycle to cycle are much smaller in amplitude than those which are apparent when pre-ignition and auto-ignition are present. Proper calibration of gate width, with due regard to normal phase eccentricities, makes this a useful means of identifying incipient auto-ignition and pre-ignition.

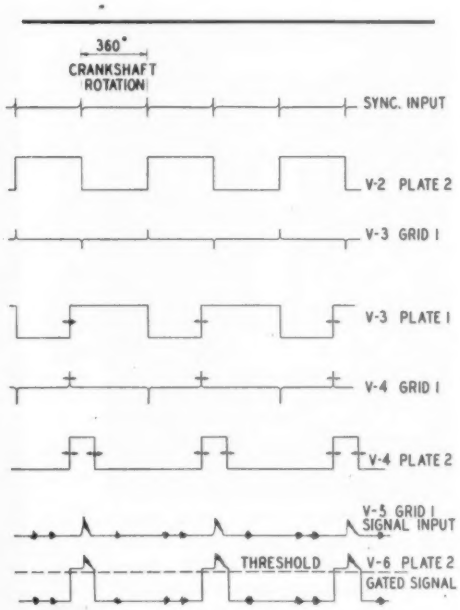

FIG. 6. Time sequence of wave forms during complete engine cycles.

3. In a number of basic studies on engine operation, it is advantageous to determine the principal frequencies present in the transducer output. Superposition of these signals on a gate of convenient time width greatly simplifies identification of the frequency of the principal component.

4. At certain times it is desirable to make a comparison of power outputs, using various fuels, or with the same fuel under various engine conditions. Quite often a dynamometer of proper size and capacity is not available. Use of the calibrated gate in conjunction with a reliable pressure pickup affords a means of plotting a pressure-versus-crank angle curve from which power ratings may be obtained. * * *

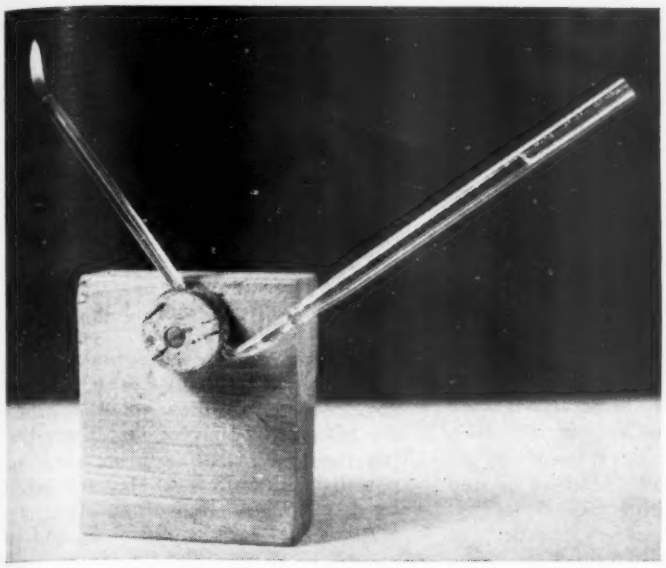

FIG. 1. **SIMPLE** but effective (micro) lamp for rapid sulfur determination. Fig. 2 is same lamp, but note sizes of the flames.

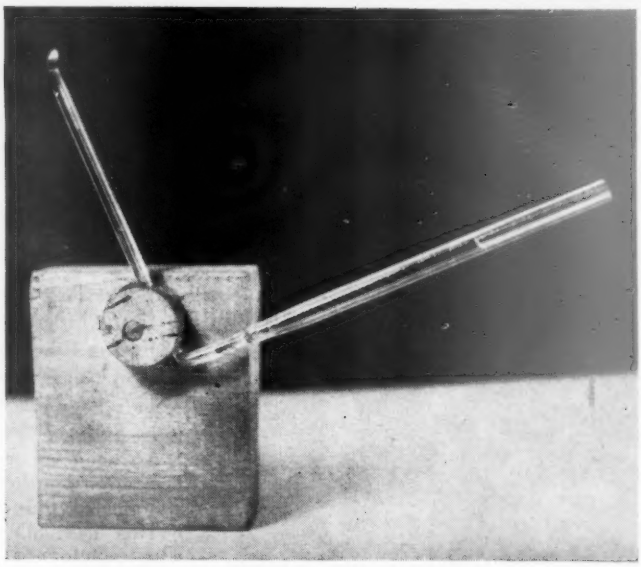

FIG. 2. **SIZE** of flame can be adjusted within wide limits by rotating cork to right or left, and varying wicking distance.

Rapid Method for Determination of Sulfur in Gasoline

WILLIS R. BATTLES*

MOST refineries occasionally have a need for a rapid method for determination of sulfur in gasoline. Such a method has been developed, which utilizes already available apparatus, for the most part. The only special apparatus required is the macro-sulfur lamp and a special chimney that are easily constructed from standard glassware.

Using this method, one man, with two lamps and three absorbers can easily run from six to eight sulfur determinations per hour with sufficient accuracy for most routine requirements. This permits running of 3 determinations per sample as standard practice for greater certainty of results, without undue waste of time.

The problems involved in the development of this method fell into four categories: (1) Development of a satisfactory lamp permitting accurate measurement of small volumes, easy adjustment of flame size and quality, and quick set up and burning of sample. (2) Efficient absorbent solution for minute quantities of SO_2 which would be satisfactory for larger amounts of SO_2 also. (3) Efficient absorber, permitting as little loss of SO_2 as possible. (4) Accurate method of determination of the small amounts of SO_2 involved—or of the acid formed by SO_2 absorption.

1 — The Lamp (Figs. 1 and 2.) The lamp, shown in Fig. 1, is made from one-half of a 2 ml pipet, calibrated in hundreths, by sealing the lower end to a five-inch length of capillary tubing (¾ mm bore, 5 mm OD). One 2 ml pipet thus makes 2 lamps.

The capillary tubing is bent at approximately a 90 deg angle 4 in. from the open end of capillary, forming an open V. The lamp is then mounted to a cork, which is fastened snugly to a wooden block by a screw. The attitude of the arms of the lamp may be varied by rotating the cork a few degrees right or left.

The wick is a 4½ in. piece of No. 40 mercerized cotton stocking thread. Inserting the wick in the capillary is accomplished by first dipping the thread in molten paraffin, removing excess paraffin and cooling. The thread so treated is stiff enough to push into the capillary, aided by suction applied at the upper end of the pipet. The paraffin is removed from the thread by soaking in benzene for several hours, occasionally changing benzene. The benzene is rinsed from the lamp with gasoline. Several 0.5 ml portions of low sulfur content gasoline are then burned in the lamp. The lamp is now ready for use.

The lamp thus constructed has these advantages:

(1) Easy flame control: By rotating cork right or left and varying wicking-distance of gasoline (Figs. 1 and 2.)

(2) Precise reading: 0.2 ml can be read with ½ per cent accuracy.

(3) Quick set up and burning: Small hold-up of wick permits easy washing, and an initial burning period of one minute for flushing lamp and adjusting flame. Average burning time per sulfur determination for a .2 ml sample is 5 minutes.

(4) Low evaporative loss: Important for volatile samples. Very small exposed evaporative surface plus short burning time keep evaporative loss at a minimum.

2 — Choice of the absorbent solution: Reactions:

(1) $H_2O_2 + SO_2 = H_2SO_4$

(2) $H_2O + \overline{\overline{SO_3}} + I_2 = \overline{\overline{SO_4}} + 2HI \gtrless 2\overset{+}{H} + 2\bar{I}$

(2a) $H_2O + \overline{\overline{SO_3}} + \bar{I}_3 = \overline{\overline{SO_4}} + 2HI + \bar{I}$

(3) $O_2 + 4HI = 2I_2 + 2H_2O$

(4) $KIO_3 + 5KI + 6HCl = 3H_2O + 3I_2 + 6KCl$

(5) $I_2 + 2\overline{\overline{S_2O_3}} = \overline{\overline{S_4O_6}} + 2\bar{I}$

(6) $SO_2 + H_2O = H_2SO_3 \gtrless 2\overset{+}{H} + \overline{\overline{SO_3}}$

All initial tests of various absorbents

*Fletcher Oil Company, Wilmington, California.

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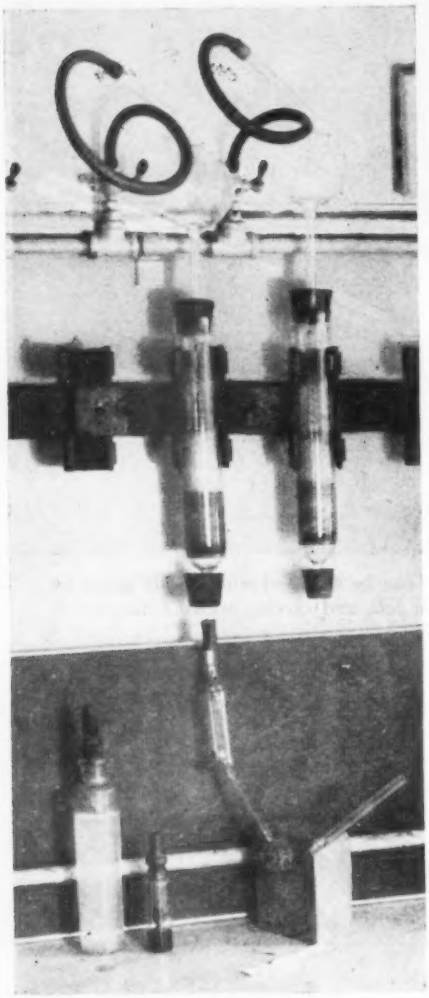

FIG. 3. MACRO sulfur determination lamp and modified Ethyl Corporation absorption apparatus assembled.

were run using the absorption apparatus of the Ethyl Corporation lamp sulfur apparatus.[1]

3% H_2O_2 (Equation 1) was tried as an absorbent solution, with poor results. Results were low and unreproducible.

10 to 30 ml of approximately .001 N $\bar{I}_3$ + starch solution was tried as an absorbent (Equation 2a) hoping to obtain a visual end point as the starch iodine blue faded, then reading the amount of gasoline burned in lamp and thus calculating the per cent sulfur in the gasoline. Some fair results were obtained at sulfur contents exceeding 0.20 per cent, but poor (very low) results were found at sulfur contents below 0.10 per cent. Apparently oxidation of the $\bar{I}$ ion present in the $\bar{I}_3$ reagent took place according to Equation 3.

A mixture of an excess of KI+KIO_3 plus a carefully measured amount of .10 N $Na_2S_2O_3$ plus a few drops of starch was next tried as an absorbent, apearance of a starch-iodine blue indicating the end point when an amount of SO_2 had been absorbed equivalent to (an experimentally determined factor for) the known amount of thiosulfate present. The theory behind this method was:

(1) 1 mol of SO_2 gives 2 mols of $\overset{+}{H}$ (Equation 6)
(2) These 2 mols of $\overset{+}{H}$ give one mol of I_2 (Equation 4)
(3) This mol of I_2 gives 2 more mols of $\overset{+}{H}$ (Equation 2)
(4) These 2 mols of $\overset{+}{H}$ give 1 mol of I_2 (Equation 4)
(5) This 1 mol of I_2 reacts with 2 mols of thiosulfate (Equation 5)

Thus 1 mol of SO_2 theoretically uses up 2 mols of thiosulfate.

As soon as all the thiosulfate has been used up, the iodine formed by step (4) gives a blue with starch.

This method gave fair results, but with a factor for .02N thiosulfate of approximately .44 mg/cc instead of the .32 mg/cc theoretical. As results were still not reliable in the low sulfur range, a better absorbent was sought.

Other absorbents tried were $KmnO_4$, KIO_3, and mixtures of these reagents. A special KI_3 starch reagent as described by Katz[2] was also tried without success.

Probably the most promising of all these absorbents was the iodine absorbent first tried, provided a means of preventing reaction[3] from taking place could be found. Elimination of KI from an aqeous solution of iodine would prevent this but would reduce the iodine solubility to an undesired extent. After much trial and error, the use of a .1 N iodine solution in methanol was chosen for a stock solution. (.3 ml of this stock solution to 15 gms ice+15 cc H_2O and a few drops of starch solution were used as the absorbent.)

The use of (zero — blank) ice in the absorbent solution cut down the loss of iodine during absorption. Again, only fair results were obtained when the fading of the starch iodine blue was used as an indication of SO_2 content. (Probably because of evaporative loss of iodine.) However, when the acid formed (Equations 6 and 2) was titrated, good results were obtained in spite of any iodine loss. This reaction of SO_2 with iodine is especially good for this procedure since 4 mols of $\overset{+}{H}$ ion are formed per mol of SO_2 absorbed, double the amount formed in the usual H_2O_2 absorption, thus doubling the standard alkali used in titration of the acid formed and increasing the accuracy, especially in the very low titrations obtained when burning less than .2 ml of low sulfur gasoline. This also tends to reduce the error due to acid formed from other constituents (which do not react with iodine) such as any HBr formed from ethylene dibromide used as a scavenger for lead in ethyl gasoline.

3. The Absorber. The Ethyl Corporation absorber was chosen in preference to the usual ASTM U-tube absorber because it had less moist surface that might absorb the SO_2 before it could contact the iodine solution. The Ethyl Corporation absorption tube is made of approximately 30 mm Pyrex tubing with a "C" porosity fritted glass disc at the bottom and with the bottom (gas inlet) tube of 7 mm pyrex tubing. Overall length is about 10 in.

A 250 ml erlenmeyer flask fits the stopper below the absorption tube. The chimney tube leads through this stopper into the flask. Fumes are thus lead into the flask and then upward through the absorbent solution. (For more details see Reference No. 1.)

Even the best results obtained with the methanol — I_2 — ice water absorbent, however, were low when absorbing the SO_2 in the conventional Ethly Corporation lamp sulfur absorption apparatus. It was thought that this might be due to absorption of moisture plus SO_2 on the walls of the flask and air oxidation of this H_2SO_3 which could thus not contact the I_2 absorbent solution. This would result in less acid formation than theoretical. To correct this fault a special chimney was constructed and fitted to the absorber as shown in Fig. 3. (This chimney was made from a 3½-in. section of a 20 mm Pyrex test tube sealed to a 1½ in. section of 1 mm Pyrex capillary tubing.) The flask and chimney were removed from the Ethyl Corporation absorber and the chimney illustrated was fastened directly to the lower portion of the absorber by a short rubber tubing. After burning was complete, the chimney and connecting tubing was removed before shutting off suction and then the flask was replaced beneath the absorber to receive the solution for analysis. Before replacing the chimney at the start of an absorption run, (with suction on) the lower portions of absorption tube were swabbed dry with a ⅛ by 3 in. roll of a piece

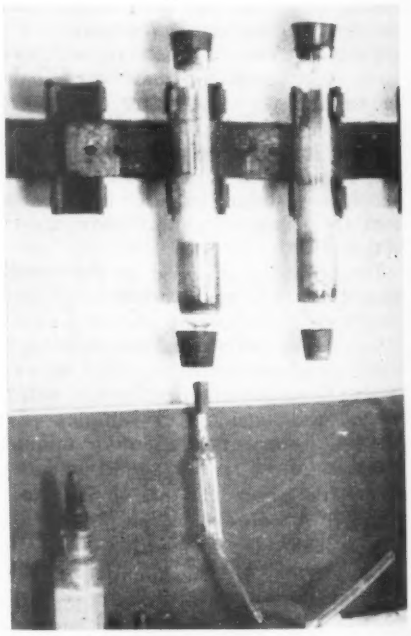

FIG. 4. BY USING two absorbers and running check tests on same sample and lamp, analyses may be checked and completed in 5-10 minutes.

of toilet tissue. The chimney was then placed in position and the absorption run made. Results were much better using this procedure.

4. Determination of SO_2 absorbed. The SO_2 absorbed was determined by titrating the acid formed during SO_2 absorption (Equations 6 and 2) after discharging any remaining starch — iodine blue with a few drops of .05N sodium thiosulfate.

The end point using methyl red as an indicator for determination of the acid formed during SO_2 absorption was not sharp enough for the desired accuracy when very small amounts of SO_2 were absorbed and titrations were made with .02 N NaOH. The end point was found to be much sharper when using an achromatic indicator consisting of 0.2 gm Methyl red + .1 gm Methylene blue in 200 cc of alcohol.[3]

With this indicator, titrations may be made to an accuracy of .02 ml of .02 N NaOH in 60 ml of solution. The color change is from violet to colorless to green. The color change from colorless to a faint tint of green was chosen as the end point in these determinations.

Determination of Sulfur in Gasolines

Appparatus and Reagents Required. Special Macro — sulfur determination lamp and modified Ethyl Gasoline Corporation sulfur absorption apparatus as described above. Ten ml micro buret, calibrated in .05 ml and with fine tip delivering .01 to .02 ml drops. (Fig. 3.)

Approximately 0.1 N iodine solution in Methanol. (Dissolve 12.7 gm of iodine in 1 liter of C. P. Methanol.) (Store in glass stoppered bottle.)

Approximately .05 N aqueous solution of sodium thiosulfate — contains 12.5 gm $Na_2S_2O_35H_2O$ per liter of water.

Special Achromatic Indicator: Dissolve .2 gm Methyl red + .1 gm Methylene Blue in 200 ml alcohol per liter of water.

Starch indicator solution — .25 per cent solution of soluble starch. Dissolve starch in a little cold water — pour into boiling water and boil for a few minutes. Cool and make up to volume.

Procedure

1. Fill a clean lamp with gasoline by inserting wick end of lamp in gasoline and applying suction to pipet end. Rinse twice with about .3 ml of gasoline, letting gasoline run out pipet end. Refill lamp and start burning at wick end.

2. While lamp burns for a minute or so place a small rubber stopper in inlet (7 mm) tubing at bottom of clean absorber No. 1. Add about 10-15 gm of pure cracked ice (distilled water ice or ice which gives a zero blank.)

3. Add .3 to .6 ml of .I N methanol — iodine solution, 6 drops of starch solution, then distilled water to total volume of about 30 ml.

4. Insert stopper at top of absorber No. 1 and start suction.

5. Remove small rubber stopper at bottom (7 mm) tube of absorber, permitting air to pass up through absorber. Swab 7 mm (bottom) tube dry with a fresh piece of rolled up toilet tissue.

6. Attach chimney to bottom of absorber with ½ in. length of rubber tubing. Be sure that glass to glass contact is made between absorber tube and chimney tube. Adjust suction to moderate rate. (Bubbles reaching to within about 4 in. of top of absorber.)

7. Adjust lamp so that a clean smoke-free flame ¼ to ⅜ in. high is obtained. (Additional gasoline may be added to lamp through top with a fine tipped pipet or glass tube.)

8. Move lamp so that flame is under chimney, simultaneously reading lamp to nearest .001 ml.

9. Burn .2 to .3 ml of gasoline — or until starch iodine blue color fades to light blue, if this occurs first. (If color fades to colorless, discard sample and start over. Burn less gasoline.)

10. Remove lamp, again reading simultaneously to the nearest .001 ml.

11. Remove chimney (and short rubber tube) from bottom of absorber. Place chimney on bottom of another prepared absorber (absorber No. 2.) Place lamp, reading volume carefully, beneath absorber No. 2 (which was made ready while above burning was taking place.) By alternating lamp between different absorbers in this way an analysis will be finished every 5-10 min.

12. Place 250 ml erlenmeyer flask in place at bottom of absorber No. 1.

13. Shut off suction on absorber No. 1 and permit absorption liquid to drain into flask. Rinse absorber and top — liquid trap bulb 3 times with small amounts of distilled water, draining rinsings into flask. Total volume should now be 60 to 80 ml.

14. Remove flask from rubber stopper. Discharge starch — iodine blue with a few drops of .05 N thiosulfate.

15. Add 6 drops of achromatic indicator solution and titrate to a faint green (persisting 5 seconds while shaking flask) with .02 N standard sodium hydroxide. Sometimes an additional 2 drops of indicator added when end point is a drop or so away will sharpen end point. A blank should be run, pulling laboratory air through an identical absorption solution for the same length of time as burning of lamp under other absorber. Subtract NaOH titration of blank before calculating sulfur content.

Notes.

1. An excess of iodine causes no harm, but no less than .3 ml of .I N iodine methanol solution per 30 ml of absorption solution should be used, since low results may be obtained. In practice, a calibrated eye dropper is accurate enough for measuring I_2 solution.

2. When finished with lamp, it should be cleaned by rinsing several times with .3 ml portions low sulfur, volatile gasoline (such as 10-20 lb R.V.P. casinghead) a third, and final rinse portion of .5 ml of the same rinse gasoline should be pulled into lamp and permitted to slowly drain through wick end by pivoting wick arm to a horizontal position.

Calculations:

$$\% \text{ Sulfur} = \frac{V \times F}{v \times d}$$

for .0200 N. Na OH
theoretical F = .0160
(Experimental F = .172 — table I)

V = ml of std. NaOH titration (after subtracting blank)
F = factor for NaOH
v = ml of gasoline burned
d = specific gravity of gasoline at its temperature.

(See Table 1 and discussion.)

Determining the factor for NaOH: Mixes of Butyl Mercaptan in Methanol and in N. hexane were prepared, having known sulfur contents. These mixes were then analyzed for sulfur content using the method outlined above. The per cent sulfur was calculated for each mix, using the theoretical F value of .0160 for the .0200 N NaOH used. Table 1 shows that the results obtained in this manner were low, possibly partially from evaporative losses and also probably because of traces of SO_2 which may have oxidized to SO_3 before reaching the iodine absorbent solution and thus gave a lower acid concentration than theoretical. By using the corrected

TABLE 1. Analysis of mixes of known sulfur content.

Using F = .0172 for .02 N NaOH

Materials in mix	Mix number	Per cent sulfur present	Per cent sulfur found*	Per cent low value	Factor for .02 N NaOH needed to give correct sulfur		Corrected value for sulfur found	Per cent error from true value
Butyl Mercaptan in methanol....	Mix I	.327	.306	6.4	.0171		.325	0.6 low
Butyl Mercaptan in methanol....	Mix II	.112	.101	9.8	.0177	Av .0172	.109	2.7 low
Butyl Mercaptan in methanol....	Mix III	.025	.022	12.0	.0182		.024	4 low
Butyl Mercaptan in n hexane....	Mix IV	.120	.115	4.2	.0168		.123	2.5 high

* Using the theoretical NaOH factor of .0160 for .0200 N NaOH
(Each result is the average of three or more analyses)

TABLE 2. Examples of typical analyses.

(Results calculated using an F value of .0172 for .0200 N NaOH)

Mix III (See Table I) .0216; .0272; .0230; .0243
Average .0240% True sulfur .025%
Mix IV (See Table I) .115; .131; .124
Average .123% — True sulfur .120%
Sample A (See Table 3) .0880; .0876; .0900
Average .0885

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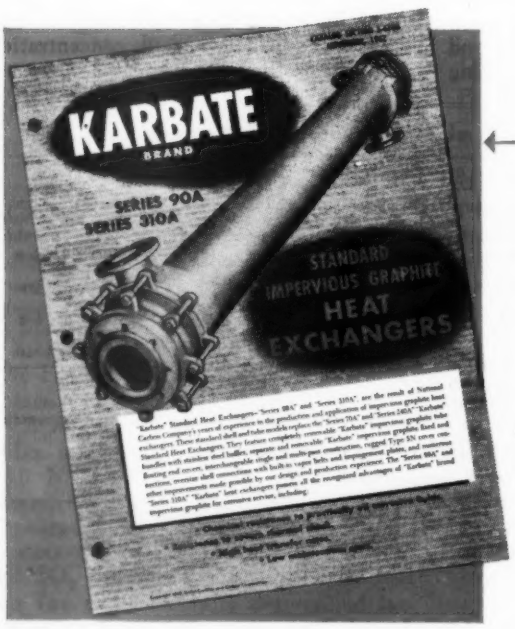

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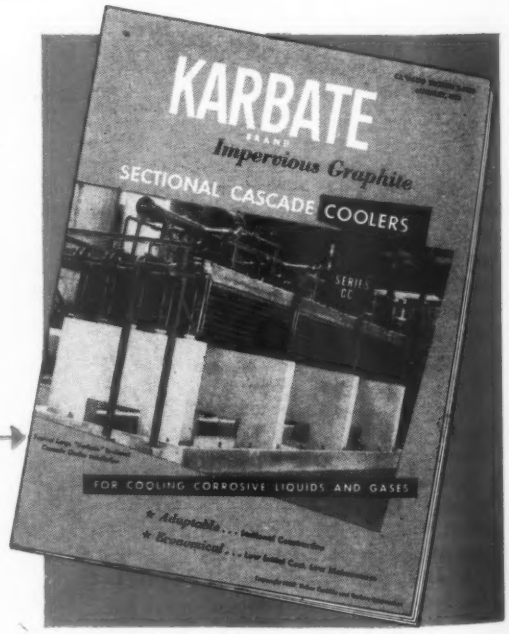

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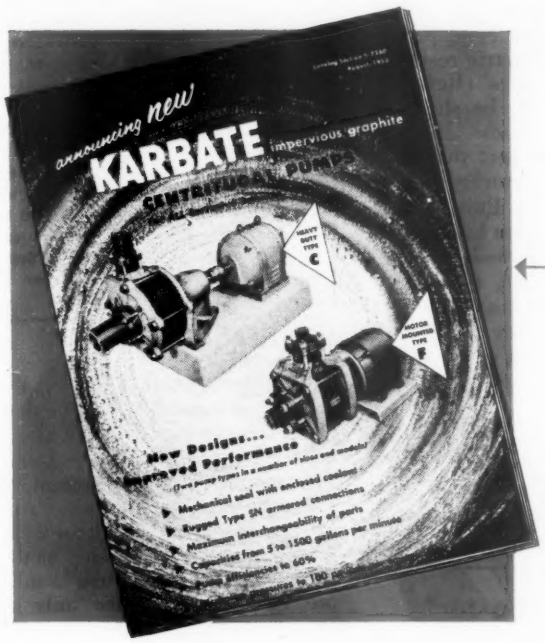

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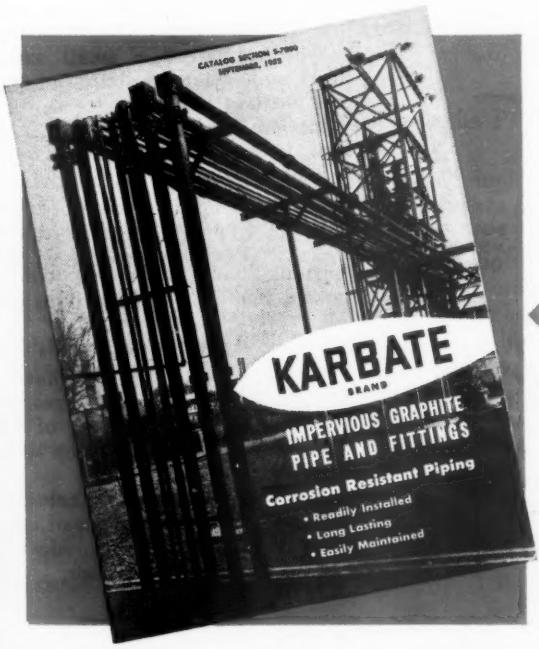

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TABLE 3. Analyses of typical gasolines for sulfur.

Sample	% Sulfur found I By rapid method	II By Ethyl Corp. method (H_2O_2 absorption NaOH titration)	III Gravimetric sulfur (from solutions after NaOH titrations of absorbents in column II)
A Catalytic cracked ethyl gasoline....	.0885 (.088)	.092	.082
B Unleaded thermal cracked gasoline..	.274	.261	.271
C Thermal cracked ethyl gasoline....	.242	.258	.247
D Unleaded 420 deg end point thermal cracked gasoline..	.395	.390	.398

F value of .0172 (Table 1), much closer agreement of results was obtained, as would be expected, since this F value was obtained experimentally and thus corrected for any systematic losses inherent in the procedure.

Discussion of Experimental Results. Table 1 shows the results of the analyses of the mixes of known sulfur content, and data used in calculating the factor F for the .0200 N NaOH.

Table 2 shows the individual results of some of the analyses of Tables 1 and 3 and indicates the magnitude of individual deviations to be expected.

Table 3 shows a comparison of results obtained by some different methods of sulfur analysis on a variety of gasolines.

The results of Samples A and C (Table 3) by the rapid method indicate that these figures are probably closer to the true value of sulfur content in these gasolines than the Ethyl Corporation method, and for sample A, probably closer than the gravimetric results. (According to ASTM figures (Ref. 4) gravimetric results tend to be slightly low for sulfur contents below .10 per cent.) It is also a known fact that the NaOH titration of H_2O_2 absorbed lamp sulfurs tend to be high for Ethyl gasolines.[5] Samples D and B gave higher results by the gravimetric method than by the NaOH titration of H_2O_2 absorbent (Ethyl lamp method) on the identical absorbent solutions. This may have been due to traces of ammonia or of nitrogen bases in the laboratory air.

Summary and Conclusions

A rapid lamp method for the determination of sulfur in gasolines has been developed. With this method the sulfur content of a gasoline may be determined in an average time of 10 min with an average error of less than 3 per cent of the amount of sulfur present, which is sufficient accuracy for most routine requirements, although not meeting ASTM requirements. This method is invaluable where less than 2 ml of sample is available, since only about .2 ml of gasoline is burned per determination. In all cases, analyses were made by burning lamps in laboratory air, with no burning in controlled atmospheres. Possibly improvements such as more efficient absorption and burning in a controlled atmosphere of O_2 plus CO_2 might make this method the equal of any present methods for accuracy while greatly conserving time and sample quantity.

The results of a small amount of work on heavier distillates indicates that this method has value for sulfur determinations on light gas oils, stove oils and kerosenes. Best results were obtained by diluting the heavier material with from 4 to 8 volumes of a light, low sulfur gasoline of known sulfur content. Such dilution gave a smoother burning flame with less tendncy to smoke than the undiluted material.

The Author

Willis R. Battles is a chemist for the Fletcher Oil Company of Wilmington, California. He is a graduate of the University of California, joining Shell Oil at the time of graduation. He worked for five years for this company and spent one and a half years with Trojan Powder Company and two years for Union Oil Company in the latter's research department. While at Union Oil he conducted a survey of the odor problems at Oleum refinery. He spent five years as co-partner-manager of California Car Bed Company, prior to joining Fletcher.

Acknowledgments

The author wishes to thank J. F. Wonder for his helpful suggestions and to thank the management of Fletcher Oil Company for permission to publish this report.

Any communications, including suggestions and data from use of this method on different types of products would be welcomed by the author.

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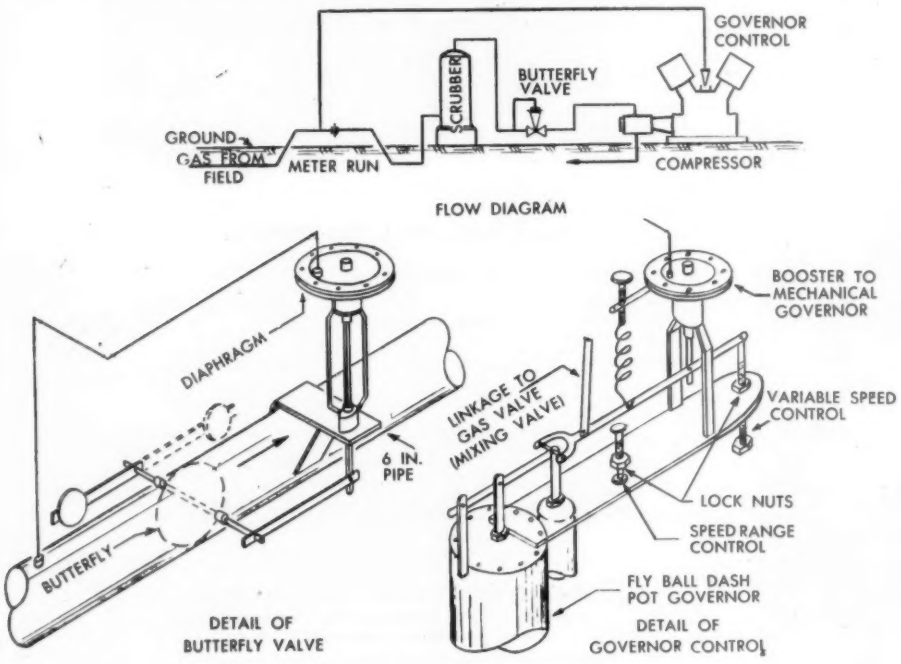
* * *

Plant Aids

Diaphragm Operated Butterfly and Governor Booster*

T. O. HAMAKER†

This is a diaphragm-operated butterfly in the suction of a gas engine with a diaphragm-operated booster on the mechanical governor of the engine that controls the pressure on the field system or can be reversed to control the engine suction pressure.



Excess pressure in the suction depresses the diaphragm in the butterfly control thus opening the butterfly valve in suction line, and increasing flow to compressor cylinder. The same excess pressure depresses diaphragm on governor booster. This movement is transmitted through linkage so that fly ball governor is forced to open up and increase rpm of engine to accomodate increased gas volume to limit as set by speed range control. Action of booster is deferred by counteraction of a coil spring, until a predetermined increase in suction has been reached.

*Class A, first prize and grand prize in NGAA Kinks Contest.

†Arkansas Fuel Oil Company, Magnolia, Arkansas.

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The Petroleum Engineer

Economics of Spares in Refineries

When is it proper to install a spare pump or compressor?
If a spare is needed, how many should be installed?

JOHN E. BELL

ONE of the knottiest problems that repeatedly presents itself to refinery engineers is how to justify permanently installed standby equipment. A request is presented for spare equipment based on the apparently sound logic that the expenditure of some relatively small amount of money for a spare pump, line, or exchanger may eliminate a major shut-down of a refinery facility and would consequently pay off in a day in the event that the regular service equipment were to fail. On the other hand this argument, when carried to an extreme, might result in the installation of complete spares for all equipment with the result that the capital investment in refining facilities would be doubled over that actually necessary to process the required amount of crude. Such a policy would, of course, bankrupt any company which attempted to follow it.

Economics is one of the factors that is involved in making a decision regarding the merits of installing a piece of spare equipment and it is the purpose here to demonstrate a method by which this one factor may be calculated. In using an economic criterion to determine the advantages of installing a piece of spare equipment it should always be borne in mind that the factors of safety, future expansion and other incalculable considerations may outweigh in importance the question of economics and dictate the installation of a piece of spare equipment in a situation where economic calculations indicate that the proposed installation is not justified.

In order to calculate the economic advantage of the installation of a piece of spare equipment, it is necessary to have the following information:

(a) Statistical data regarding the probability of failure of equipment similar or identical to that for which a spare is proposed. This is expressed as failures per year.

(b) An economic study which provides an estimate of the loss resulting from a shut down caused by equipment failure. This should be expressed as dollars lost per failure.

(c) The cost of installing the spare equipment.

It is then necessary to assume a good value for pay out. In the petroleum industry a two or three year pay out before depreciation and income taxes is usually considered to be the criterion of a good investment. In some instances a longer pay out may be acceptable. In order for the installation of spare equipment to be advantageous its cost must be less than the product of loss per failure, times failures per year, times years to pay out.

Statistical data on the frequency of failure of particular types of equipment such as pumps, compressors, fans, etc., are not always available. An "educated guess" at this figure, however, probably results in a more accurate analysis of the problem than an off-hand guess at the entire question of whether or not a spare is justified.

Calculation of the loss resulting from a forced shut-down may prove to be a major task when the problem involves an existing unit. Decisions regarding permanently installed standbys, however, are usually made during the design of a new unit. At such times economic studies are almost always available and can be used as a basis for the calculations.

One of the situations that is easily overlooked in considering problems of this type is the case where the refining facilities are not operated at their peak capacity in order to meet market demands. In the event that a particular facility operates at less than peak capacity, it is possible to catch up after a forced shut-down and as market demands are met at all times there is little real economic loss resulting from the failure of the facility to operate continuously.

Although it is questionable that the problem of the installation of spares has, in the past, been attacked by these methods, it is obvious that the collective judgments of the people who have made these decisions has been in accord with the results that would have been attained from more rigorous study. This is evidenced by the customs in the refining industry with regard to the installation of spares on electrical systems. In most instances a continuous supply of electrical power is essential for continued operation of the entire refinery and thus a failure of the electrical system will result in a large loss in profit. Further, the cost of spares for transformers and switch gear is relatively small in proportion to the loss which may result from failure of this type of equipment. It thus appears logical to install spare equipment for electrical transformers and switch gear and a review of commercial installations will show that this policy is almost always followed.

Another problem that arises particularly on a major project is how to provide spare equipment at minimum cost. An example of this problem would be the installation of a boiler plant in a refinery where it has been decided that a spare boiler is essential. If it is assumed that the normal steam demand is to be 1,000,000 lb per hour, there are numerous alternatives that may be selected. First, the installation might include two 1,000,000-lb boilers thus providing for normal operation with spare equipment available in the event of failure. A second alternative would be the installation of three units each of 500,000 lb capacity. A third alternative would be the installation of four units each of 333,333 lb capacity, etc.

It will be noted that the alternatives

The Author

John E. Bell, assistant chief engineer of the manufacturing department of Sinclair Refining Company joined the Sinclair organization in 1934 in the research and development department at East Chicago. In 1943 he was project engineer on the construction of Sinclair's refinery at Corpus Christi, upon completion of which he returned to East Chicago as project engineer on the propane deasphalting unit, phenol treating unit, and MEK dewaxing unit, as well as several other projects.

In 1949 he was put in charge of the Central Engineering Department at East Chicago and moved to his present position with headquarters in New York in 1951. Bell was graduated from Rensselaer Polytechnic Institute in 1932. He received his Master's degree in chemical engineering from Massachusetts Institute of Technology in 1936.

EXCLUSIVE

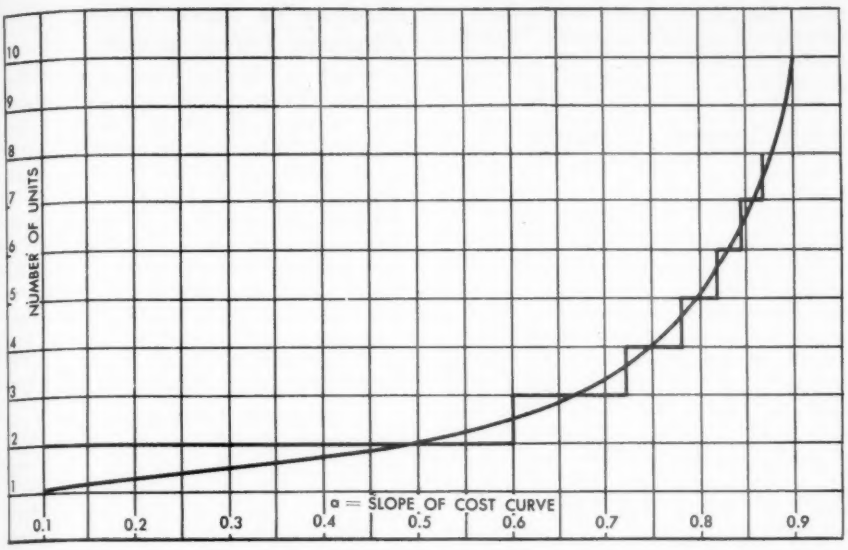


FIG. 1. Curve for estimation of optimum number of units for minimum capital investment.

listed all contemplate the installation of a multiple number of identical units. This is the usual practice in a multi-unit plant because it simplifies operation and reduces the investment in repair parts. For this reason the calculations that follow are all based on a multi-unit plant with all units being identical.

The selection of the number of units depends on many factors. There are always special situations that are unique to particular problems and these must not be overlooked. There are, however, some factors involved in all such decisions. These are:

a. Safety
b. Operating costs.
c. Plans for future expansion.
d. Capital cost.

This article will give consideration only to the matter of capital cost. A mathematical equation can be derived that will indicate the number of units that should be installed in order that the capital cost of the entire plant will be a minimum.

It must first be assumed that the capital cost of the units that will be installed in the plant is an exponential function of their capacity. This rule is accepted by estimators and it is discussed by Nelson in his series of articles on "Costimating."[1]

This relationship is expressed by the equation:

$$\text{Cost A} = \text{Cost B}\left(\frac{\text{Capacity A}}{\text{Capacity B}}\right)^{a}$$

The exponent, a, varies with the type of equipment under consideration. Nelson gives a listing of exponents he considers to be correct for various types of equipment. With this relationship accepted the total cost of a multiple unit plant with one spare unit can be expressed as:

$$K = X^{a} Q \left(\frac{1}{x} + 1\right)$$

where

K = capital cost of complete plant.
Q = cost of a single unit with capacity equal to the normal design operating capacity of the plant.
X = unit size expressed as a fraction of the normal design operating capacity of the plant.
a = exponent of the capital cost equation.

From this equation it can be derived that K will be a minimum when

$$X = \frac{1-a}{a}$$

The curve shown on Fig. 1 is a graphical representation of this equation. For convenience the ordinate is plotted as number of units, which is $\left(\frac{1}{x} + 1\right)$ rather than X. The abcissa is (a), the exponent of the cost-capacity equation.

In applying this procedure to the boiler plant for example, we would select a value of 0.7 for a. This is the figure which Nelson[1] recommends for complete plants and a large boiler would fall in this category.

In order to provide figures for an example, it will be assumed that a single boiler together with its auxiliaries having a capacity of 1,000,000 lb of steam per hour would cost $5,000,000. Based on the exponential rule we can calculate the cost of the various alternatives as follows:

2 Units	$10,000,000
3 units	9,240,000
4 units	9,280,000
5 units	9,500,000

The three unit plant involves the lowest capital expenditure. This may be verified on Fig. 1 for an exponent of 0.7.

In selecting an exponent consideration must be given to the cost of the entire installation.

As an example, consider the case of a small pump, where the exponent according to Nelson for reciprocating pumps is 0.7. This would indicate that where a spare is required the installation should consist of three pumps. A more careful analysis will include the cost of foundations, piping manifolds, extra building space, etc. The cost of these items will be practically independent of unit size. The exponent for the cost of the entire installation will fall below 0.6 and the correct number of units to install for minimum capital cost is two.

The problem of how much to spend on spare equipment is certainly a complex question. The methods which are outlined in this article cannot provide the final answer in all cases. They will, however, serve as an aid to judgment and it is felt that such calculations are worth while in instances when major capital investments are involved. * *

[1]Oil and Gas Journal, October 5, 1950.

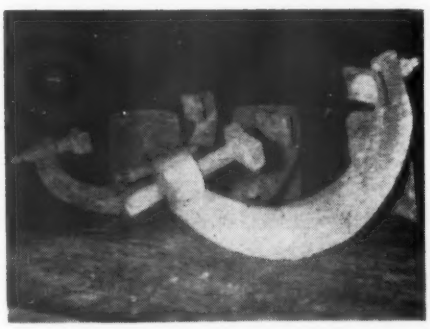
Plant Aids

Line Repair Clamp

BEN HALLEY†

This is a type of C-clamp especially shop made for high strength and to fit pipe of a given diameter.

To repair a leak using this clamp, a piece of soft neoprene large enough to cover the leak and any pitted area, is first centered over the leak and held in place by a piece of string. During this phase, liquid is of course, spraying from beneath the neoprene. A piece of steel, usually cut from pipe and hammered to fit the pipe size being repaired is then centered over the neoprene and the clamp is installed and tightened with a wrench until the leak has stopped. The steel patch can then be held with bands installed with a Bandit tool and the clamp can be removed. It is satisfactory, also to leave the clamp in place and not use bands. In either case, as soon as the gasoline has evaporated from the bell hole the patch can be welded to the pipe and the bands or clamp removed.



†Warren Petroleum Corporation, Gladewater, Texas.

Class C, Second Prize, NGAA Kinks Contest.

News

Foreign Refining Capacity To Show Increases; PAD

Refining capacity in free-world nations outside the United States will by the end of 1955 be 40 per cent greater than it was at the end of 1951, Acting Deputy Petroleum Administrator Rea Jackson has predicted.

Refineries in the Far East will have increased their capacities by 77 per cent over the period, and European refiners will have increased their capacities by 47 per cent.

Western Hemisphere refiners outside the United States, on the other hand, plan only a 28 per cent increase in capacities over the period. No major expansion is planned in the Caribbean area, which figures so largely in Western Hemisphere output.

Statistics show that foreign refiners plan significant increases in the installation of modern refining processes such as catalytic cracking and, even more, catalytic reforming.

McNutt Refiining Expands

McNutt Oil and Refining Company has announced it has put on stream a UOP Platformer as the culminating step in a modernization program that has increased the capacity of its refinery in Brickland, New Mexico. High octane Platformate being produced in the 600-bbl per stream day Platforming unit is being blended with other stocks to supply McNutt's retail outlet, as well as several distributors, and to meet demand for premium quality gasoline and distillates.

C. Blaine McNutt, refinery president, said construction of the Platformer was handled by refinery personnel, who also revamped two existing facilities.

A UOP two-coil thermal cracking unit is being converted into a three-coil unit, and the crude capacity will be increased from 3000 to 4000 bbl per stream day and the capacity of the thermal cracker from 1200 to 1800 bbl per stream day. A new stabilization unit is being added to the thermal cracker, and the capacity of an existing UOP poly plant will be increased 33⅓ per cent.

Octane Number May Rise

Gradual increases in octane numbers of gasoline and in compression ratio of automobile engines, resulting in an eventual saving of three-quarters of a billion dollars a year to American motorists, were predicted by William M. Holaday, director of Socony-Vacuum Laboratories, Socony-Vacuum Oil Company, Inc.

Although the cost of gasoline per gallon probably would be a little higher as a result of these developments, the motorist would still save money because the cost of gasoline per mile would be less than with today's gasoline in today's engines. In addition, the lower fuel consumption would ultimately result in substantial conservation of crude oil, probably as much as 400,000 bbl a day.

Holaday said that improvements in engine design and fuel manufacture in recent years make it practical to raise octane numbers up to 98 and compression ratios up to 10 to 1.

Egloff Speaks in Japan

Dr. Gustav Egloff, director of research for Universal Oil Products Company, has been in Japan, where he played a leading role in the 75th anniversary celebration of the Chemical Society of Japan. Dr. Egloff was the only American to address the Society. As one of three invited foreign lecturers, he spoke on "The Platforming Process" and "Chemicals from Petroleum" at Tokyo and "Catalytic Reactions in Oil Refining" at Osaka during the week of the celebration.

Shell Refinery Set Up

Shell Oil Company has announced a new 50,000-bbl refinery for Anacortes, Washington. General contract has been granted the Bechtel Corporation. Actual field construction of the refinery units will begin about the middle of 1954, F. S. Clulow, Shell vice president in charge of manufacturing, announced.

Major refining units will consist of a crude oil fractionating unit, a platformer, and a catalytic cracker.

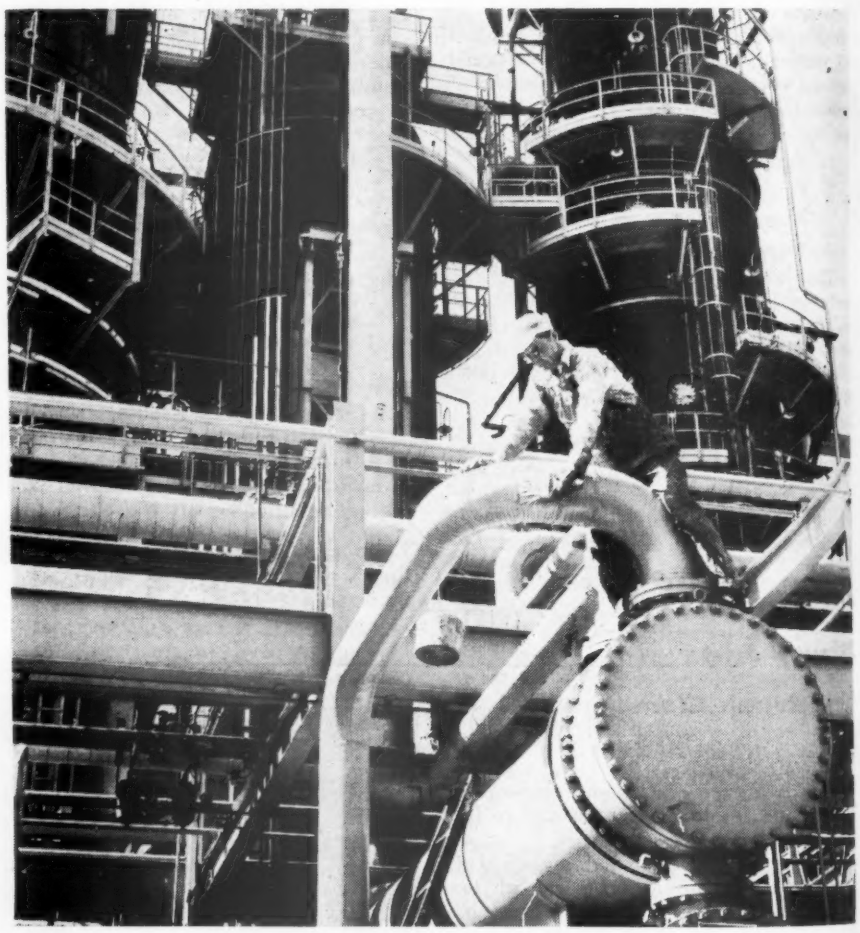
Sinclair to Have New Chicago Office Space

Peter B. Ruffin, president of the Suffolk Corporation, has announced that Sinclair Refining Company has signed a 25-year lease for 150,000 sq ft of space in the new 10-story, office building, now being constructed by Suffolk Corporation, Chicago, Illinois. The new structure — the first new office building to be erected in the Chicago Loop area since the 1930's — will be known as Sinclair Oil Building and is due for completion in June 1954.

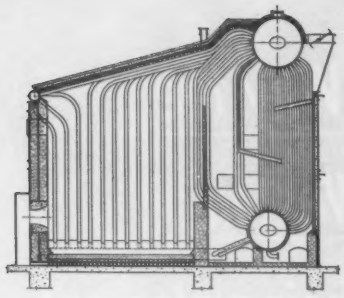
Cat Cracking Unit on Stream

Ben Franklin Refining Company put on stream recently a new UOP high conversion fluid catalytic cracking unit. The new unit is designed for 5000 bbl per stream day of fresh feed stock at 75 per cent conversion, with a coke burning capacity of 7550 lb per hour.

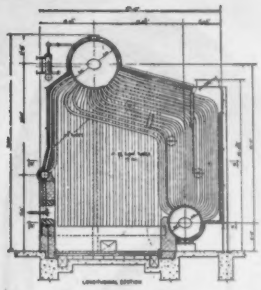
With the new cat cracker, a gas concentration, a polymerization, and a LPG unit also were placed in operation. A thermal cracking unit was revamped into a single coil cracking unit to handle the catalytic cycle stock. Still under construction is a vacuum distillation unit, which will be used to prepare saleable asphaltic materials and feed stock for catalytic cracker.



FINISHING TOUCHES are given new 24,000 bbl fluid catalytic cracking unit dedicated recently at Esso Standard Oil Company's Everett, Massachusetts, refinery. Multi-Million dollar expansion and modernization of the plant gives New England its first complete oil refinery and is part of more than $23,000,000 spent or earmarked by Esso for new manufacturing and marketing facilities throughout New England in the last five years.



2 Drum Water Tube Boiler



Type-S 2 Drum Boiler Series S1

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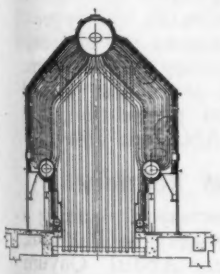
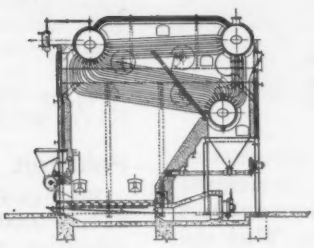
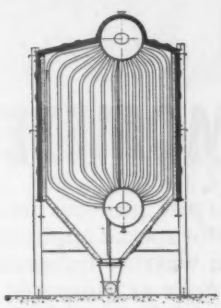


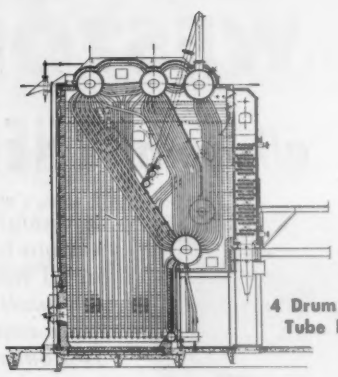
"A" Type Water Tube Boiler



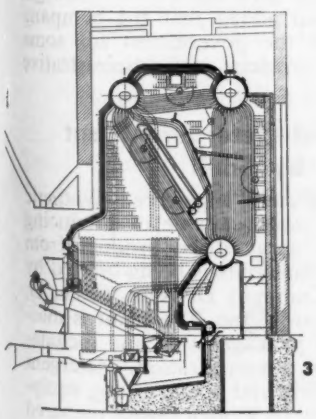
3 Drum Low Head Water Tube Boiler



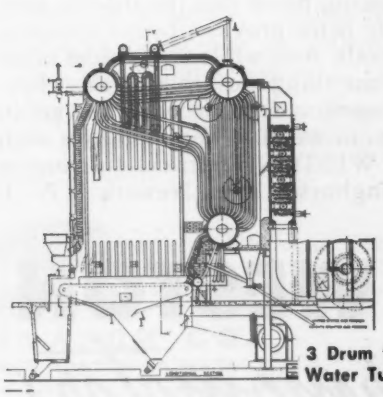
Wickes 2 Drum Waste Heat Installation



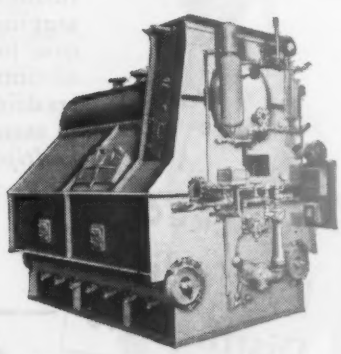
4 Drum Water Tube Boiler



3 Drum Water Tube Boiler



3 Drum "B" Type Water Tube Boiler



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Although WESTON provides sensing elements of various forms for special applications, the element in all standard WESTON Industrial Thermometers is a *multiple helix* as illustrated above. Why the more costly *multiple,* instead of the single, helix? *Just one reason.* WESTON's twenty years experience producing bi-metal thermometers for industry has furnished convincing proof that the shorter, non-sagging *multiple* helix provides better accuracy, over longer periods. And while it provides other advantages, the one thing most thermometer buyers demand is long-term dependability. You get it, in extra measure, in WESTON Thermometers with *multiple* helix. WESTON Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

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News

Anglo-Iranian Oil to Use Gamma Rays for Welding

Another in the growing list of industrial applications of atomic research will be employed by Anglo-Iranian Oil Company during construction of its new Kwinana refinery in Western Australia. The company announced that gamma rays, in addition to X-ray, will be used to inspect the miles and miles of pipe line welding that will go into the building of the 62,000 bbl-a-day plant. Radio-active isotopes, the company said, will be flown to Australia from Britain's Atomic Research Station at Harwell. The Kwinana refinery is being built near Fremantle by Anglo-Iranian's associate company, Australasian Petroleum Refinery Ltd.

Pan-Am Fellowship Granted

Five fellowships for the school year 1953-54 have been renewed by the Pan American Refining Corporation, and one new fellowship established, L. W. Moore, president of Pan American, and Dr. P. C. White, manager of the research and development department, announced. Grants were renewed at the University of Illinois, Massachusetts Institute of Technology, Rice Institute, University of Texas, and University of Kansas. The new fellowship was granted to the University of Arkansas.

NLGI Wins SAIE Award

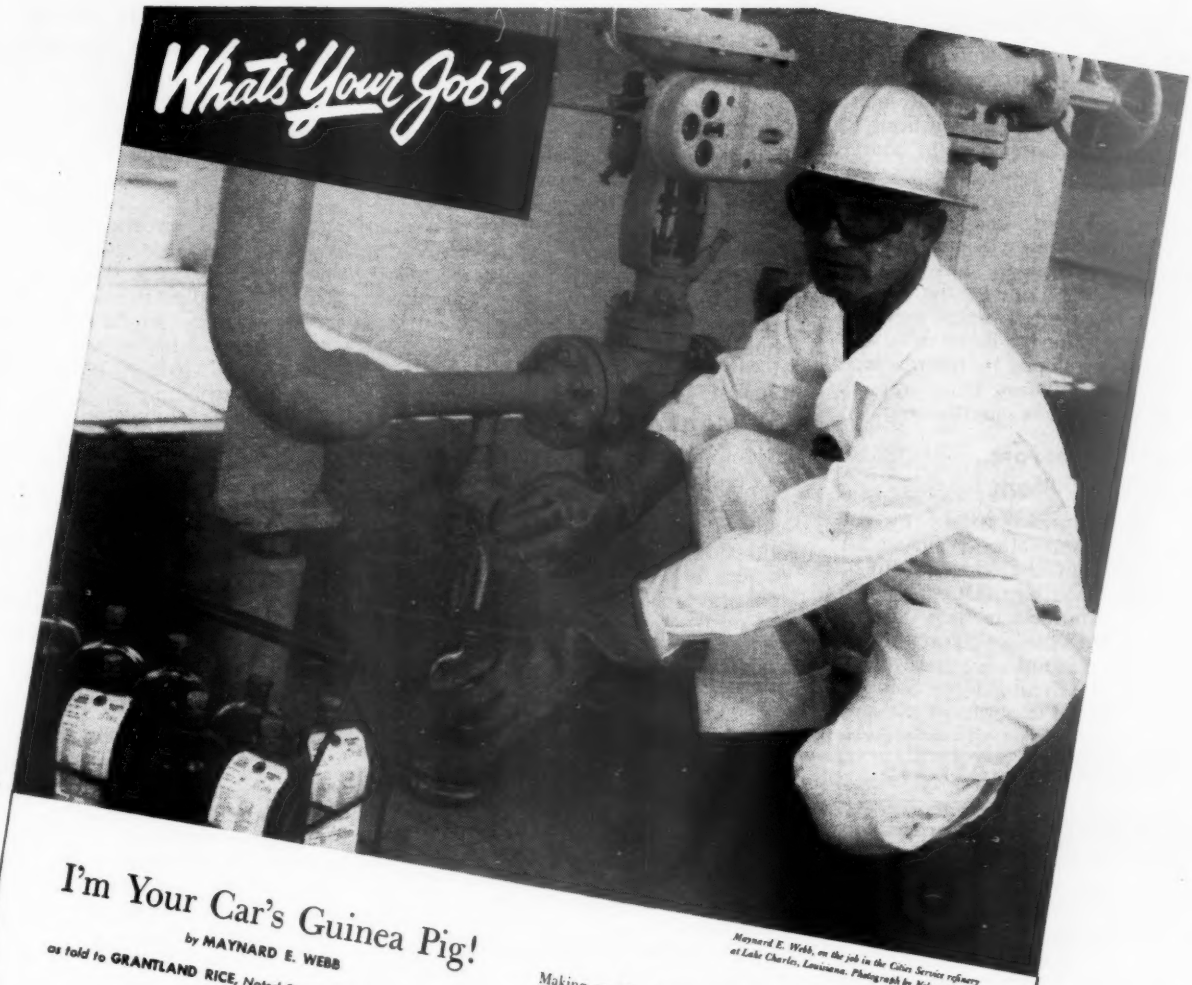
W. W. Albright, president of the National Lubricating Grease Institute, has announced that the Institute has won the top journalistic award offered each year by the Society of Associated Industrial Editors. Known as the "Award of Excellence", it is given the industrial publication considered by the Society to have the best appearance and content among the approximately 600 competing publications. This is the third journalism award won by its official publication, the NLGI SPOKESMAN since 1949.

Pakistan to Get Refinery

Burmah Oil Company is planning a $21,350,000 oil refinery in Pakistan, industries minister Abdul Qayum Kahn told parliament in Pakistan recently. The minister reported that the plant would turn out 140,000,000 gal a year, and added that the company had asked the government for some technical, financial, and administrative help.

Packaged Detergent Plant Offered by Snell

A completely engineered synthetic detergent plant, capable of producing a finished spray dried product from basic raw materials is being offered by the Hull Company Division, Foster D. Snell Research, Inc. The plant is marketed as a packaged unit and includes sulfonation, neutralization, detergent compounding and spray drying equipment. Based on a plant layout prepared to suit the customers site and conditions, all piping is precut and marked.



Maynard E. Webb, on the job in the Cities Service refinery at Lake Charles, Louisiana. Photograph by Nelson Morris.

I'm Your Car's Guinea Pig!

by MAYNARD E. WEBB

as told to GRANTLAND RICE, Noted Sportswriter and Commentator

THEY TRY OUT the gasoline on ... If our reaction ...

... every 15 minutes, test up to 20 different ways, and report our findings.

We couldn't be fussier if we were making baby food.

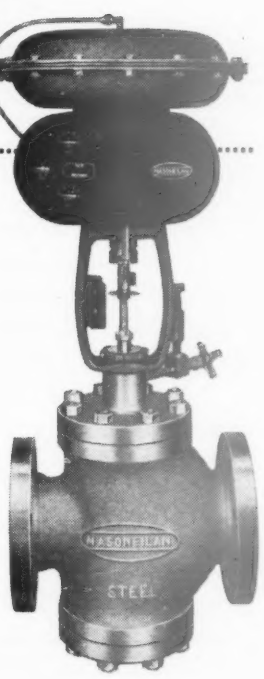
Making gasoline is a lot like making baby food, at the ... compression engine is as sensitive to ... formula. When a baby ... "someth...

... of course, is over-simplifying the care we take to turn out a fine gasoline. A book could be written on the subject. But I think you'll agree that we guinea pigs are probably the most important people in this refinery—from your car's point of view, that is.

CITIES SERVICE

Masoneilan 10000 Series Valve and 7000 Series Positioner at work in Cities Service refinery at Lake Charles, Louisiana

If your job is selecting Control Valves



get acquainted with the quality features which distinguish *Masoneilan* Control Valves. Learn about the built-in accuracy, stamina and economy which has induced thousands of quality-conscious companies like Cities Service, all over the world, to select Masoneilan valves as an important element in maintaining the quality of *their* products. Put Masoneilan Control Valves to work for you — helping maintain the quality of *your* product. Complete information on request.

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News

Pan-Am Unit Planned

A fixed-bed hydroforming unit incorporating the latest design features will be built at the El Dorado Refinery of Pan-Am Southern Corporation, R. T. Colquette, vice president in charge of manufacturing, announced.

Construction will begin in October, Mr. Colquette said, and ground on which the new unit will stand is already being prepared for construction.

The unit will be one of the first of its kind in the United States and will incorporate new design features as well as a catalyst developed by the research department of Standard Oil Company of Indiana, Pan-Am's parent company.

Sunray to Operate New Coking Plant

The Ucan Products Company has awarded the construction contract for its projected delayed coking unit to be built at Sunray Village (Duncan), Oklahoma, in conjunction with Sunray Oil Corporation's catalytic cracking refinery, to The Lummus Company.

The plant is scheduled for completion late in 1954. Functions of the new unit will be to produce from a straight run residuum charge material (approximately 13 deg gravity) a maximum quantity of gas oil for charging to Sunray's catalytic cracking unit.

Designed capacity of the new coking unit is 9000 bbl per day, or when operating at capacity approximately 120,000 tons of coke per year. The plant will also upgrade No. 6 fuel oil into a variety of more valuable demand products including propane, propylene, butane-butylene, debutanized gasoline and gas oil, for additional catalytic charging stock.

Union to Build Reformer At Montana Refinery

Union Oil Company of California will construct a 600-bbl-a-day catalytic reformer and other facilities at its Cut Bank, Montana, refinery. Engineering and design work for the $600,000 project is well advanced, a company spokesman said.

Construction of the reformer and all auxiliary facilities will be begun early next spring by the Ralph M. Parsons Company of Los Angeles.

Foreign Lubricating Oil To Be 53,100 B/D in 1954

Free-world refiners outside the United States plan production of an average of 53,100 bbl a day of lubricating oils during 1954, Acting Deputy Petroleum Administrator Rea Jackson announced.

That output would represent almost a 60 per cent increase over the actual production of 33,200 bbl a day during 1952.

Figures on prospective production were gathered during a recent survey by the Petroleum Administration for Defense on planned refinery expansion abroad.

Below is a summary of lube-oil production for 1952 and expected production for 1954:

Lube Oil Production B/CD — (42 gal bbl)	Actual 1952	Expected 1954
Canada and Mexico	5,300	8,000
Caribbean and Venezuela and Colombia	5,300	8,600
Balance Western Hemisphere	800	1,100
Total Western Hemisphere	11,400	17,700
Free Europe	18,200	30,000[1]
Africa, Middle and Near East	—	—
India, Australia and Far East	3,600	5,400[2]
Total Eastern Hemisphere	21,800	35,400
Total Free Foreign World	33,200	53,100

[1] UK–42 per cent; France–27 per cent; Germany–15 per cent; Italy–11 per cent.
[2] Japan–80 per cent.

Canada to Get First Portable Processing Plants

Canadian Palmer Stendel Oil Corporation will build the first portable gas processing plants ever to be constructed in western Canada within the next few months. Agreement for the building of these plants has been made between Canadian Palmer and California Standard Company, subsidiary of Standard of California and Canadian Gulf, a subsidiary of Gulf Oil, and others.

Union Conducts Shale Retorting Tests for Brazil

Union Oil of California is conducting pilot shale retorting tests for the Brazilian government at Union's Wilmington refinery, it was disclosed recently.

Three hundred tons of Brazilian oil shale will be processed in an experimental retort to determine whether an 8000 bbl per day commercial plant nar Sao Paulo, Brazil, using Union's retort design, would be feasible. If constructed, this would be the first commercial shale oil plant in the western hemisphere, according to Dr. Clyde Berg, Union's manager of process development.

The pilot runs are being witnessed by a six-man commission representing the Brazilian government, headed by Jose Shore. Also present are representatives of the U. S. Bureau of Mines' synthetic fuels division, and engineers of the Kellogg Company and Foster-Wheeler Company, who may install the unit in Brazil.

Union Lets Contracts To Begin Modernization

Union Oil Company of California has announced the assigning of contracts totaling $5,750,000 for construction at its Oleum (California) refinery of the initial unit in the company's $40,000,000 program "designed to obtain more and higher octane gasolines" from its crude oils.

A contract with C. F. Braun and Company calls for completion of a Platformer by November, 1954. Construction is not expected to begin before early next year. The Platformer will have a daily feed capacity of 14,500 bbl of gasoline stocks. This catalog reforming unit is licensed by Universal Oil Products.

A contract with the Bechtel Corporation calls for construction of outside facilities, utilities, and tankage that are required for the Platformer operation.

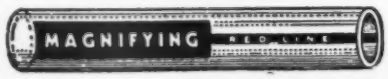
AIOC Plan Platformers

Platforming units are to be built at six refineries operated by Anglo-Iranian Oil Company and its associates, the company announced. At Llandarcy, in south Wales, the platformer will be in addition to the large current expansion program now nearing completion, while at the Kent plant, south of London, the installation will form a fourth stage in the refinery's construction plan.

In addition to the United Kingdom plants, two refineries on the Continent — Lavera, in southern France, and Hamburg, Germany — will have platformers, as will the refinery now being built at Aden, near the southern end of the Red Sea, and Kwinana refinery, which is under construction near Fremantle, Western Australia.

All the platformers will have a capacity of about 5000 bbl a day except that at Aden, which will process approximately 10,000 bbl daily.

GLASSES & GASKETS



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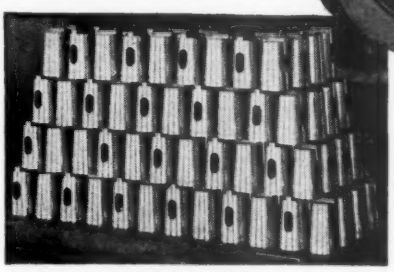
The ***Petroleum*** **Engineer**

P. O. BOX 1589 DALLAS 1, TEXAS

This Monel tube bundle used in an HF Alkylation Unit Dehydrator Reboiler is an excellent example of the use of Monel to resist corrosive chemical attack even at high operating temperatures.



These plugs for 2-inch plug valves used in hydrofluoric acid alkylation service were machined from Monel rod. No. 140 Monel Arc Electrodes are used for overlaying steel plugs in larger valves.

How Monel muzzles HF ...even at high temperatures

Monel lined hydrofluoric acid regenerator column with 1/16" minimum lining of Monel. The two Monel grids are for holding the Raschig rings.

Anhydrous hydrogen fluoride and hydrofluoric acid are good and valuable servants. ***But*** they have to be controlled with a firm hand.

Allowed to have their own way, they'll chew right through most materials. Some materials resist the dry or highly concentrated acid but succumb to dilute solutions; other materials act in the reverse.

But it's a different story with Monel®!

Experience in hydrofluoric acid alkylation units has proven that Monel is usefully resistant to attack by aqueous HF in all concentrations at temperatures up to 250° F.—with anhydrous acid and steam-HF mixtures, Monel shows good resistance at temperatures as high as 1100° F.

Monel is comparatively insensitive to the effects of velocities which increase the corrosion rate of other materials. Therefore, it is suitable for valves, pumps and pipe lines, for impellers, stators and shafts, and for bubble caps and linings in hydrofluoric acid distillation columns.

It does not acquire a scale when exposed to anhydrous HF which makes it especially useful for moving parts having close clearances, such as plug valves and pump rings.

In addition to excellent chemical characteristics Monel provides its well-known physical properties . . . high strength . . . easy fabrication and welding.

It is advisable to place equipment orders with your supplier well in advance of scheduled use. Distributors of Inco Nickel Alloys can supply the latest information on availability from warehouse and mill.

And if you have a special metal selection problem, Inco's Corrosion Engineering Section will be glad to help. Write them today. Write also for your free copy of "Corrosion by Hydrofluoric Acid," reprinted from The Oil and Gas Journal.

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MONEL . . . *for minimum maintenance*

REFINING AND PETROCHEMICAL

PERSONALS

C. H. Marshall has been promoted to the rank of technical specialist by the technical service division at Humble Oil and Refining Company's Baytown, Texas, refinery. Educated at Louisiana Polytechnic Institute, Marshall was awarded the B. S. degree in chemical engineering in 1942. As a technical specialist, his activities will be primarily in the fields of process designs of new installations and following their initial operations in the plant.

N. T. Stover has been elected vice president in charge of marketing and **R. E. Luton,** Vice President in charge of refining of The Ohio Oil Company. Stover was formerly general sales manager and Luton was manager of the refining division. Stover began his career with Ohio in 1913.

Establishment of the two new vice presidential offices follows the recent election of **C. Z. Hardwick** as executive vice president.

John L. Ham has been named director of the metallurgical research department, National Research Corporation. He assumes the position formerly held by James H. Moore, who became general manager of the company's wholly owned subsidiary, Vacuum Metals Corporation. Ham holds B.S. and M.S. degrees in metallurgy from Pennsylvania State College. He joined National Research Corporation in 1952 as project manager in charge of physical metallurgy.

Aubrey (Abe) D. Hill was named assistant manager of manufacturing, lubricating oils and waxes for all Sinclair refineries. Hill joined Sinclair at the East Chicago refinery in the development department in 1923.

He transferred to the New York office in 1944 in the division of manufacturing of lubricating oils and waxes, a position he held prior to his present appointment. He was graduated from the University of Illinois.

Linden G. Collier has been advanced to shift foreman for General Petroleum Corporation's Torrance, California refinery. He had been asphalt plant foreman at the company's Vernon, California refinery since 1948.

Collier's oil company service dates back to 1923 when he was employed by the Gilmore Oil Company, which was consolidated with General Petroleum in 1946.

J. C. Stauffer has become a patent attorney for Standard Oil Company in the general office at Chicago, Illinois. **D. R. Carmody,** a group leader, has succeeded him as a senior patent advisor at the company's Whiting, Indiana, research laboratories. **R. M. Alm,** a chemist, has been appointed a group leader in the chemical products division at the Whiting laboratories.

Dr. Stauffer did undergraduate work at the University of Washington, received his Ph.D. degree at Columbia university and his law degree at De Paul. He joined Standard in 1928.

Dr Carmody holds a bachelor's degree from St. Ambrose college and master's and doctor's degrees from the University of Iowa. He came with Standard as a chemist in 1950. Dr. Alm, a graduate of Monmouth college, received his doctorate at Ohio State university. He joined Standard as a chemist in 1948.

Thomas B. Kimball has been named general manager of refineries, Sinclair Refining Company. He succeeds John W. Duckett, who is retiring after 35 years of service with Sinclair. Kimball joined Sinclair in 1930 in the research and development department at East Chicago, Indiana. Before he was transferred to the New York office in 1943, he was in charge of the cracking division and of the process engineering and development of light oil processes at the East Chicago refinery. In 1950, he was appointed assistant manager of refineries, which position he held prior to his present appointment.

Elmer B. Palmer, manager of the Los Angeles refinery, Union Oil Company of California, has been transferred to the head office. **Henry C. Meiners,** manager of the Oleum refinery, will replace Palmer.

John W. Towler, chief refinery engineer at Los Angeles' refinery, will replace Meiners.

Ferril M. Miller has been named resident plant engineer for Cities Service Oil Company's Chicago terminal and compound plant. As resident plant engineer, Miller also will head the technical service department of the plant.

Roy Petterson will succeed Miller as resident chemist at plant's laboratory.

Byron M. Kern has been promoted to the position of chief engineer, and **Robert A. Byorum** assistant chief engineer, Spencer Chemical Company.

Kern will succeed **George F. Klein, Jr.,** who has resigned to accept the position of chief engineer of the Refinery Engineering Company at Tulsa, Oklahoma.

Kern was graduated from the University of Kansas in 1943 with a B. S. degree in chemical engineering. Following his graduation he worked for the General Chemical Company of New York City. In 1946, he was employed by Spencer.

Byorum was employed by this company in 1948. He was named project engineering supervisor in 1951, which position he now holds. He is a graduate of the University of Oklahoma.

C. W. Humphreys

W. V. Ischie

L. L. Henning

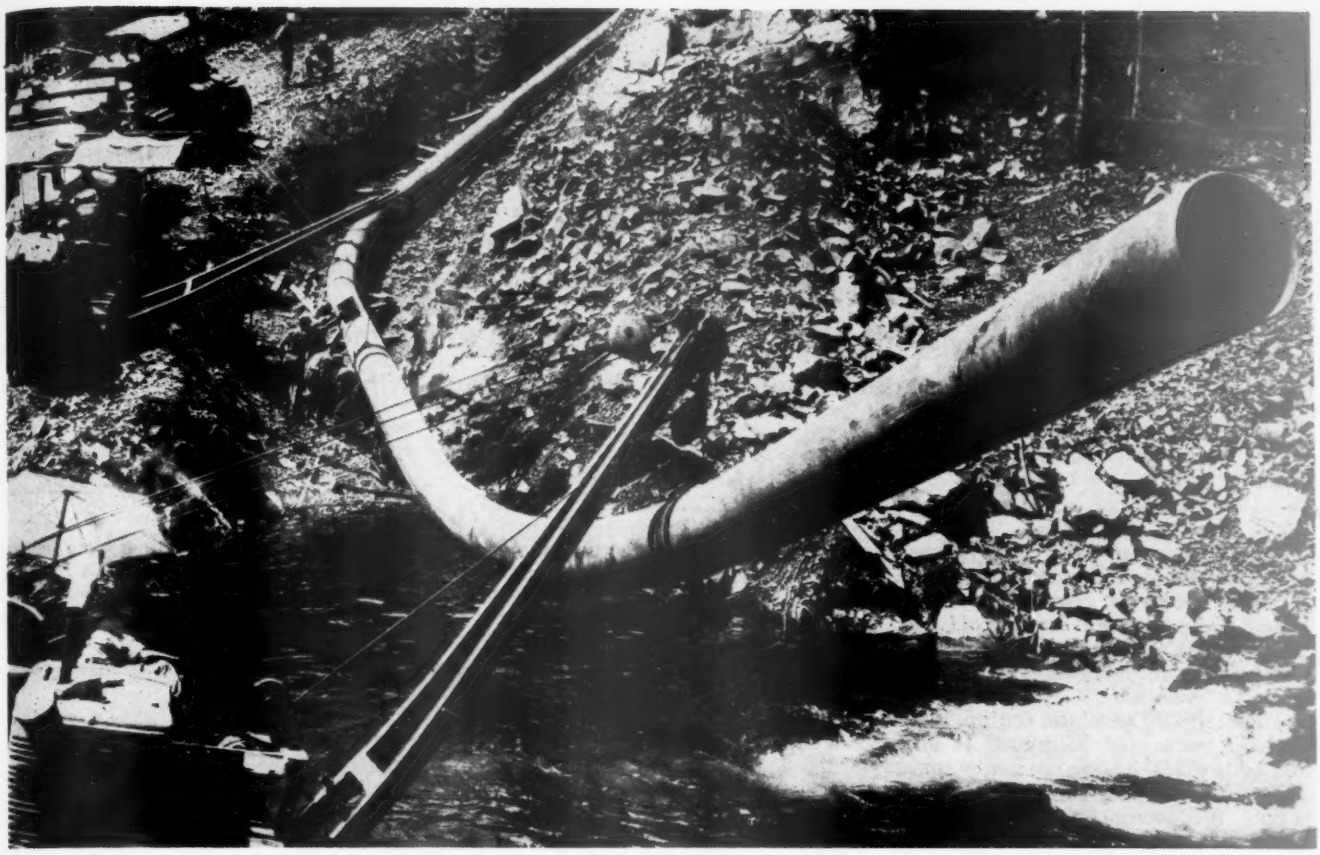
Cecil W. Humphreys has been appointed vice president in charge of manufacturing for Shell Chemical Corporation. Humphreys had previously been general manager and manager of development for the company's manufacturing department. Humphreys was graduated from College of the Pacific in 1927 and received his Ph.D. in chemistry and engineering from Stanford University in 1931. He joined Shell Chemical as a laboratory assistant and in 1946 he became manager of operations nation wide in Shell Chemical's manufacturing department.

W. Vaughn Ischie has been named as assistant manager of light oil operations, Sinclair Refining Company. Ischie joined the research department of the Sinclair Refining Company at East Chicago in 1920. In 1929, he was transferred to the manufacturing department, later becoming operating superintendent of the East Chicago refinery, which position he held until 1952, when he was granted a year's leave of absence to accept the position of director of the foreign refining division of the Petroleum Administration for Defense in Washington, D. C.

L. L. Henning has been named manager of the Bakersfield refinery of Standard Oil Company of California, succeeding **M. M. Moore,** who retired.

Moore, head of the Bakersfield plant for the last 10 years, joined Standard in 1913. He began as a chemist in the company's El Segundo refinery and later served in managerial capacities at both El Segundo and Richmond refinery.

Henning, previously superintendent of the Richmond refinery chemical division, has been with Standard since 1934. He began in the company's general engineering department and for the last 12 years has been in the cracking division at Richmond.



IN THIS ISSUE—

Part Old, Part New is the story of Service Pipe Line Company's Carrollton, Missouri, pump station. The hybrid station was constructed partly from new material, partly from the remains of the system's 36-year-old unit that was retired from service. The new station is completely electrified, quite modern, uses less space, is more efficient. See page D-4.

Electric Motors of all types are found in pipe line service these days. Numerous factors must be considered, however, in selecting the right motor for each job. These include insurance requirements, protection of life and property, climate, operating conditions, and location of equipment.

Automatic Gaging of tanks 150 miles away is now an everyday occurrence at the Ohio Oil Company dispatcher's office in Lima, Ohio. Addition of remote tank level gaging equipment with existing wire communication faclities used to carry the signals make the operation possible. See page D-19.

Safety in design and operation of natural gas pipe lines is the foremost consideration of planners and operators of such lines. In areas where gas lines have recently made their appearance, however, there has been much apprehension. The author points out that gas transmission lines are as safe as human ingenuity can make them.

Power Cleaning of in-place pipe lines may be the answer to your problem. Three methods of cleaning are in use today, with mechanical cleaning the principle method. In this field are two classifications, hydraulic and power cleaning. The author discusses uses, advantages and disadvantages of the power cleaning method. See page D-32.

Inch-by-Inch is the way the builders describe the construction of the Trans Mountain Oil Pipe Line across the Canadian Rockies. The new line will carry Alberta crude to the Pacific Northwest. Full details of the new Canadian system will be found on page D-53.

Part Old, Part New

How to Build a Hybrid Station

Converting its Carrollton station from diesel to electric operation, Service's men built a "building within a building" with good results

CARL I. HUSS

SERVICE pipeliners at Carrollton, Missouri, believe their newly completed station is one of the nicest in the entire system, even though it is "half old and half new." The Carrollton station was converted from diesel to electric operation this year.

The original Carrollton station, built in 1917, measured 95 by 40 ft and housed two 250-hp engines and pumps. Through the years more space was added to accommodate additional units, until eventually the building measured 66 by 325 ft and housed eight pumps and diesel engines totaling 10,000 hp.

Service construction men literally built "half a building within a building" in converting the station to electric operation. This had several advantages:

(1) The same station site and part of the old structure was used.

(2) The station continued operation as diesels came out and electric units replaced them. Little down time was lost during the switch-over.

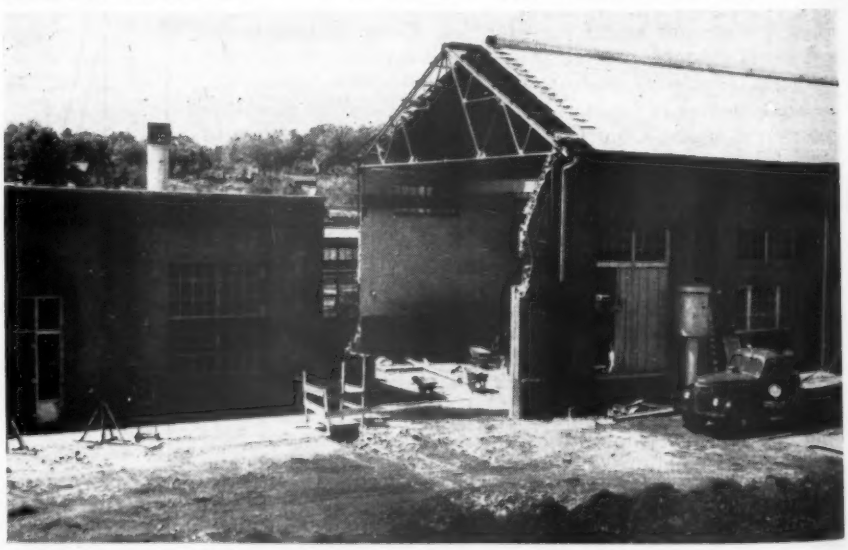
(3) Brick masons laid bricks while enjoying the comfort of steam heat. They worked during the coldest weather, something they certainly could not have done had they been

EXCLUSIVE

The Author

Carl I. Huss is editor of *The Connecting Rod*, employee publication of Service Pipe Line Company. He is a graduate of the University of Missouri, where he received his degree in journalism. He spent five years in the Army Air Corps as radio operator and technician, entering college upon his discharge from service. Huss joined the publications section of Service Pipe Line after his graduation from the University of Missouri in 1949.

LOOKING east in portion of old pump room not used in new building. Note stepped down floor level necessary to line up drive shafts of engines on other side of fire wall (right) with some types of pumps. Floor level in new pump room had to be built up to level of motor room. This portion of building was razed after old pumps and engines were taken out.



OLD STATION remains at right, new station at left. New station was completed inside old building, then walls and ceiling of old building were torn away. Remaining portion of old building at right houses old diesels and pumps away from weather until disposition of them can be made.

working outside. The men were able to run the concrete foundations during freezing weather.

Here's how the men constructed the "hybrid" station:

First, they removed two 250-hp units located in the west end of the building. This gave them room to install temporarily two 1500-hp electric motors and centrifugal pumps.

Putting the two electric units into operation gave enough pumping capacity so that three diesel units could be removed. As soon as the diesels were taken out, new concrete floors and foundations were poured for the electric units and centrifugal pumps. In the engine room the diesel foundations were broken down 2-ft below the floor and in the pump room the floor had to be raised to level it with the new motor room.

When the new floors and foundations were poured, three 1500-hp motors and pumps were installed. This relieved another diesel and the two temporarily installed electric units.

In the meantime brick masons were erecting a wall across the engine room that would serve as the west wall of the new building. They erected what would be the entire 155-ft south wall of the new building about 11 ft in from the old wall (Fig. 1). Removal of the fourth diesel gave room also to erect the east wall of the new station. They partitioned the western portion of this "building within a building" into one large room for control panels and two small rooms for storage and a restroom.

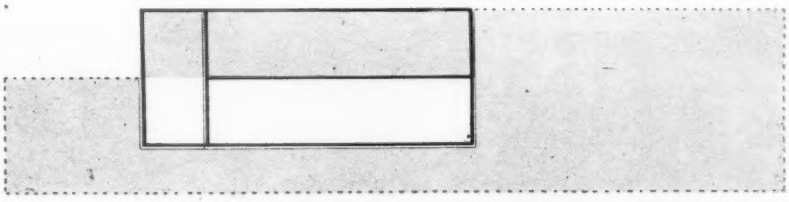
The firewall between the engine and pump room was not changed.

The old engine room measured 22 ft from the floor to the eaves and had a gabled roof. The old pump room had a 17-ft ceiling and a flat roof. For the new station the roof of the motor room was built flat and on a level with the old pump room roof (Fig. 2). With the roof completed, the station was ready for the unveiling.

This was done by first removing the old roof sheets, then rigging up an extension on a dragline boom and lifting

NEW STATION pump room before completion. Centrifugal pumps are in operation, but floors have not been tiled and walls and ceiling remain unpainted. A large window, rear, opens into control room for lighting and ventilation. Width of pump and motor rooms in new station are same.

FIG. 1. OVERHEAD VIEW of Carrollton station. Heavy line outlines new station; dotted line, part torn away. Shaded area is old station, white area is new room built inside old building before it was removed. Such arrangement allowed brickwork to continue despite inclement weather.



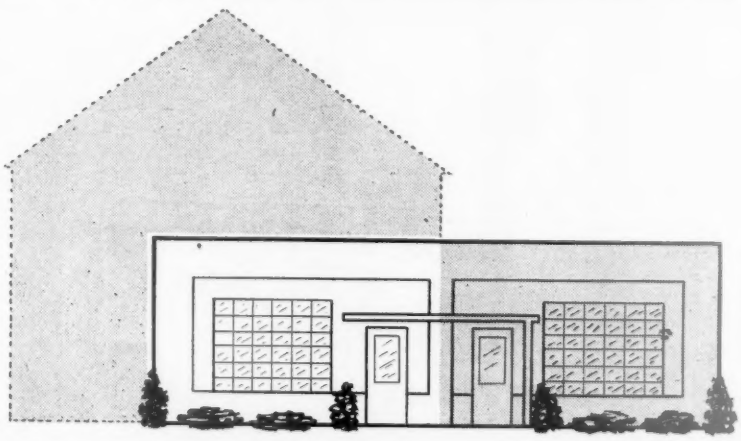
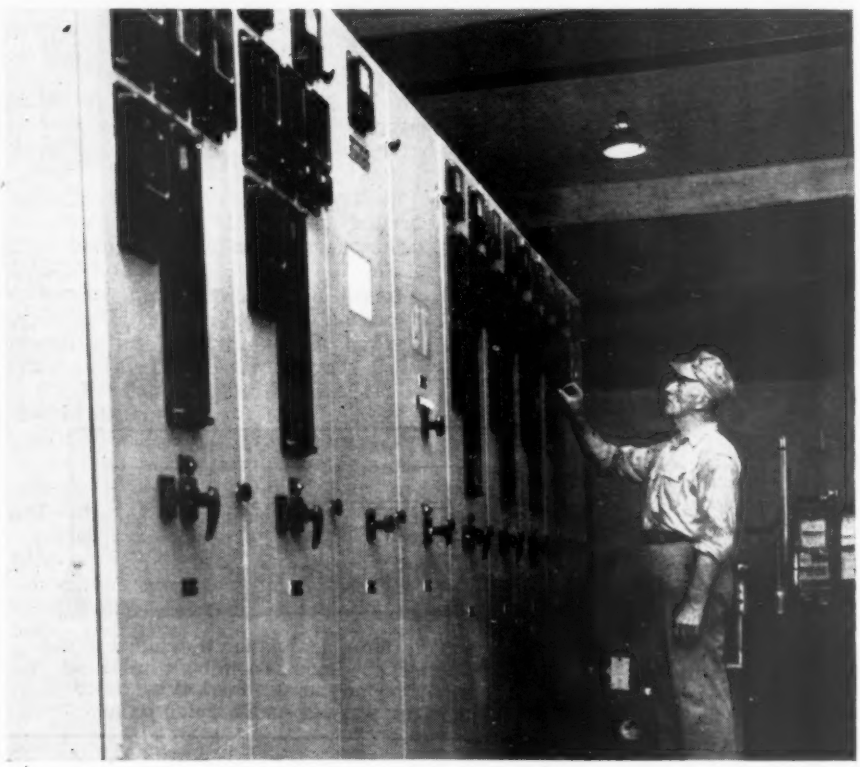


FIG. 2 END VIEW OF Carrollton station shows new station in relation to old. Shaded area was old building. White area is new motor room built inside old engine room. Portion torn away (formerly engine room) is marked by dotted lines. Low flat portion of old building, right, was old station pump room.

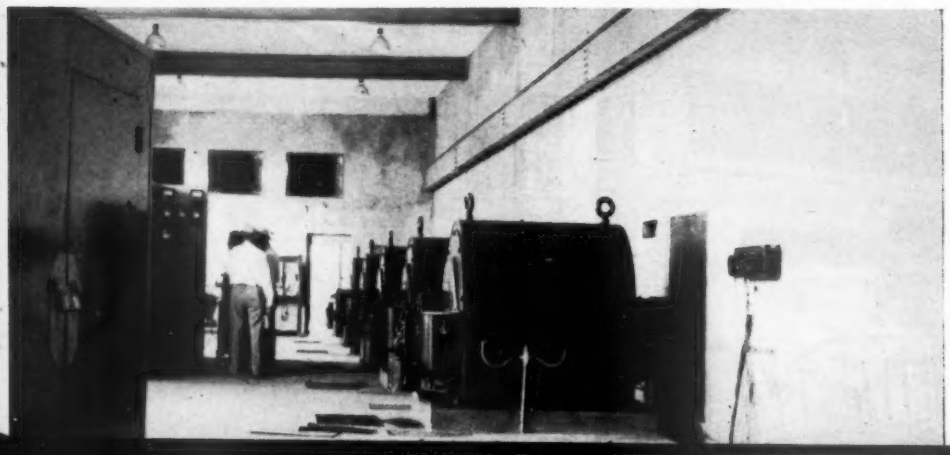
EXTREME west end of old Carrollton station, right, stands with its east side open like a child's dollhouse. This portion of building housed office, remained in use until new station completed. **WORKMEN,** left, add a modernistic front on west end of the new station. Door at front opens into station's control room. Long horizontal windows, ventilate store room and locker room facilities. Exterior of new building is brick and concrete. Interior is painted light green and floors covered with brown and red plastic tile.

SERVICE Pipe Line Company's Carrollton, Missouri, station before remodeling. Heating plant (second building from right), water tower, and manifold (behind trees left) were eliminated. Size of pump station reduced from 66 by 325 ft to 55 by 155 ft. Low, flat-roofed portion of main building housed pumps; high, gable-roofed portion housed diesel engines.



ENGINEER takes reading on one of electric motors. Units may be controlled from this panel or another one in control room. All pictures were taken before station was completed.

FIVE 1500-HP electric motors replaced eight diesel units in the old station. Motor room is slightly pressurized to minimize danger of fire and explosions from gases. Doors, at rear, leads into control room.



off the roof trusses. Next, the bolts at the steel column bases were cut, hooked onto the old brick walls and pulled over with tractors.

This removed only the roof and walls surrounding the new building, and left the rest of the old building standing as shelter for the remaining diesel units and pumps until later disposition. The extreme west end of the old building, the portion that housed the office and toilet facilities, also was left standing until the new office and facilities were completely installed and furnished.

Five 1500-hp motors drive three single-stage and two six-stage centrifugal pumps. The units are controlled either from panels in the motor room, or control room. The motor room is slightly pressurized to minimize the danger of fire or explosion from inflammable gases.

Acoustical board covers the ceilings and plastic tiling covers the floors. Ceilings and walls are painted a restful light green, the floors, brown and red tile.

The switch-over from diesel to electric units cut down the space needed from 66 by 325 ft to 55 by 155 ft. Even though the length has been halved and the number of pumping units reduced from eight to five, capacity has not been sacrificed. Maximum throughput during the summer was 325,000 bbl per day.

By halving the building length, considerable savings have been effected in building maintenance and heating bills, no small item in north central Missouri's climate.

Since some of the units were installed as far back as 1930, 1928, 1922 and 1917, maintenance down-time sometimes ran high. The new electric units give "half old, half new" station more reliable and steady throughput. * * *

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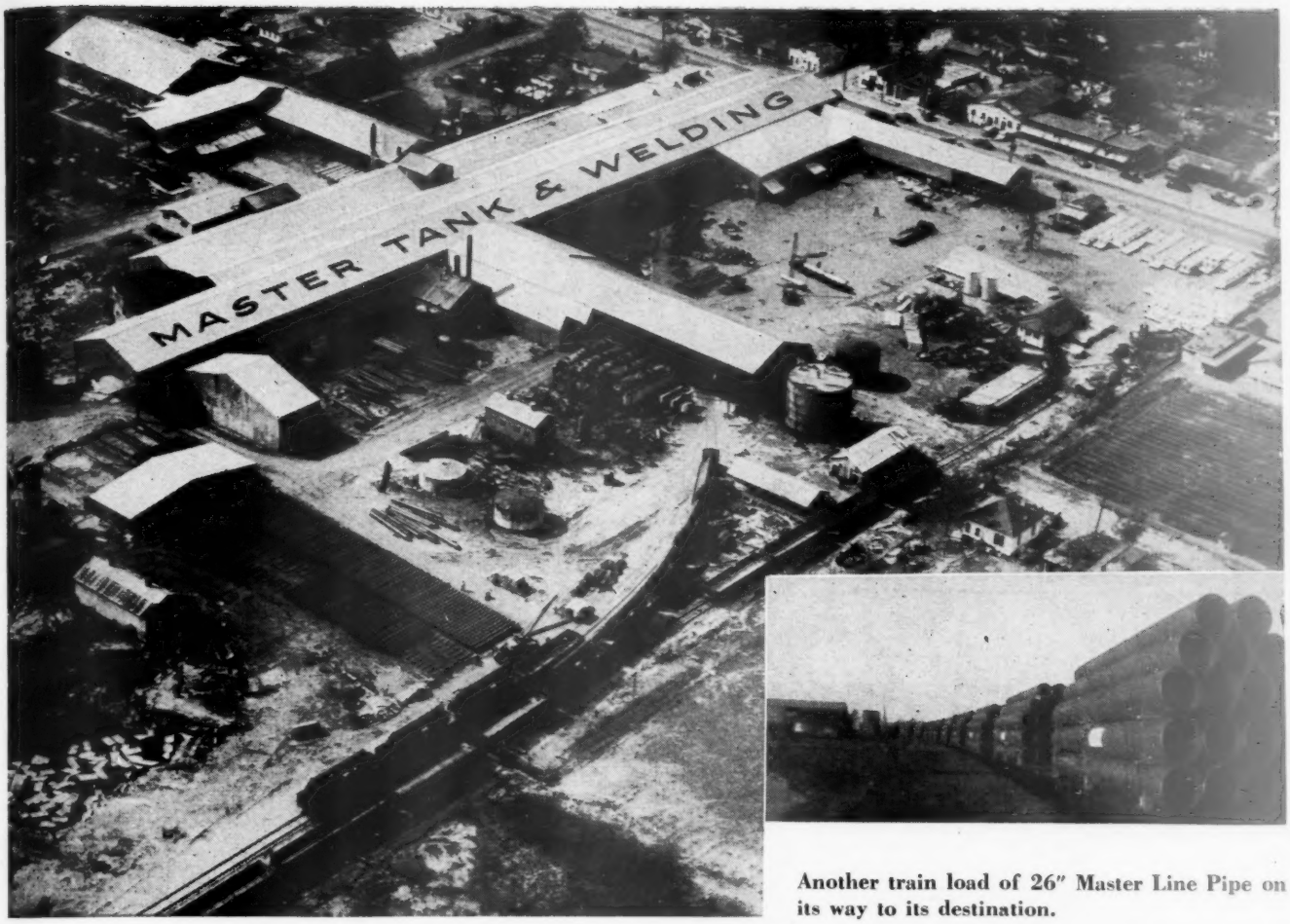
New demands for petroleum have brought orders for oil tankers that rival the size of big passenger liners. Some tankers will be 45,000 tons.



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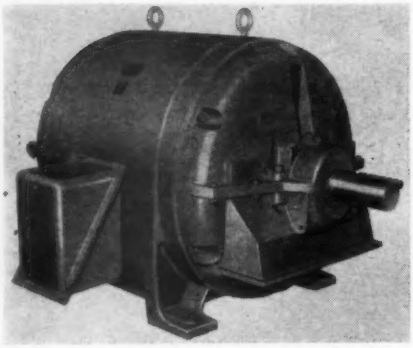
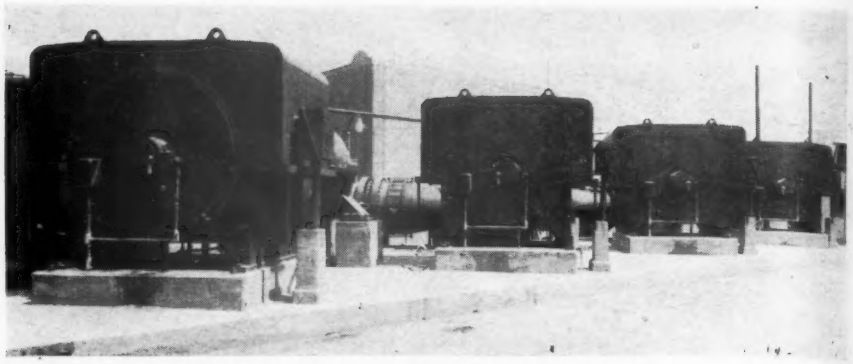


OPEN-TYPE, splash-proof 250 hp electric motor.



BANK OF four 1750 hp, 3575 rpm weather protected, open-type motors driving pumps.

Many Types Available

Pipe Line Applications of Electric Motors

Selecting electric motor for pipe line use depends on many factors, including choice of enclosure, effects of heat, insulation, auxiliary equipment and shaft alignment

E. F. GREIWE

THE type of electric motor to be selected for pipe line stations is dictated by the pipe line engineers' operating experience, insurance requirements, protection of life and property, how the station is kept and operated, whether the equipment is inside or outside, and the hazardous nature of the liquid handled.

Some pipe lines use open drip-proof motors indoors with no fire-wall, and depend on good housekeeping and possibly the elimination of dangerous fume concentrations.

Other pipe lines use open drip-proof motors indoors with the shaft extending through a firewall to the pump. Others use pipe-ventilated motors indoors with a firewall and with either the inlet or discharge opening of the motor open to the room. These motors may be self-ventilated if the duct is of sufficient size and is not too long or have too many elbows. Forced ventilated motors are also sometimes used on pipe lines.

Some pipe lines use motors with ducts connected to both the inlet and outlet openings of the motor. Generally these are of the totally-enclosed, pipe-ventilated or base-ventilated types, and are usually forced-ventilated. Usually, for such motors, inlet air is taken in at a high elevation near the top of the building, and forced through the motor by a separate blower driven by a small explosion-proof motor. These motors are generally installed in same room as pump, with no firewall.

Most pipe lines use Class I group D motors in the sizes available in explosion-proof construction and install them either indoors or outdoors, without a firewall. The tendency today seems to be toward more outdoor installations.

This article is divided into four divisions to serve the pipe line engineer as a reference on specific questions and problems. Each division covers a phase of electric motor application that should be considered in selecting new equipment and for maintenance and repair problems that may arise.

Divisions are as follows: 1—Enclosures; 2—Heat and Insulation; 3—Auxiliary Equipment, and 4—Alignment.

THE AUTHOR

E. F. Greiwe has been with Allis-Chalmers Norwood Works for nearly 18 years and is currently application engineer in the motor sales section of the electrical department of that company, in Norwood, Ohio. He specializes in the application of electrical motors in tough, corrosive locations, and travels extensively as part of his work. An electrical engineering graduate of the University of Cincinnati, Greiwe served 2½ years with the Navy during World War II. He is a member of numerous technical organizations and has presented many papers at technical conferences in the petroleum and electrical industries.

EXCLUSIVE

Open Type Motors

Open types of motors have ventilating openings which permit passage of external cooling air over and around the windings. Open, drip-proof, splash-proof, weather-protected, and some pipe-ventilated motors fit into the general open category.

Open and Drip-Proof. Open and drip-proof motors by the very nature of their protection, are for indoor installation or for use in a protected place.

Splash-Proof. Splash-proof motors are generally intended for indoor or protected locations where the motor is subject to conditions no worse than occasional splashing, such as might occur where leakage from a centrifugal pump may occasionally spray on the motor drive. Splash-proof motors should not be used outdoors in areas of heavy rainfall or where drifting snow may clog the ventilating openings. For even though these motors are fairly well protected, they are still one

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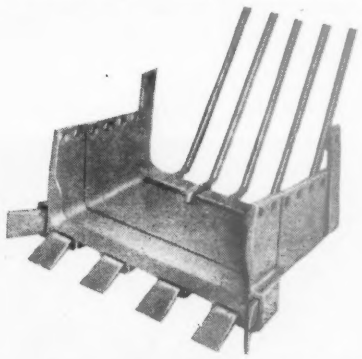

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ENCLOSED-TYPE drip-proof 25 hp motors are used to drive fans on jacket water-cooling units at Kosciusko, Mississippi, booster station on Texas Eastern Transmission Corporation's gas line.

of the open types, where external air passes over the winding and fine droplets, mist, or snow may be carried into the motor by the air stream and deposited on the windings.

Splash-proof motors at one time were fairly widely used for outdoor installations. Today the totally-enclosed types are being used more and more for outside and dirty atmospheres.

Weather-Protected. The weather-protected motor is an open machine with ventilating openings designed to minimize the entrance of rain, snow and air-borne moisture.

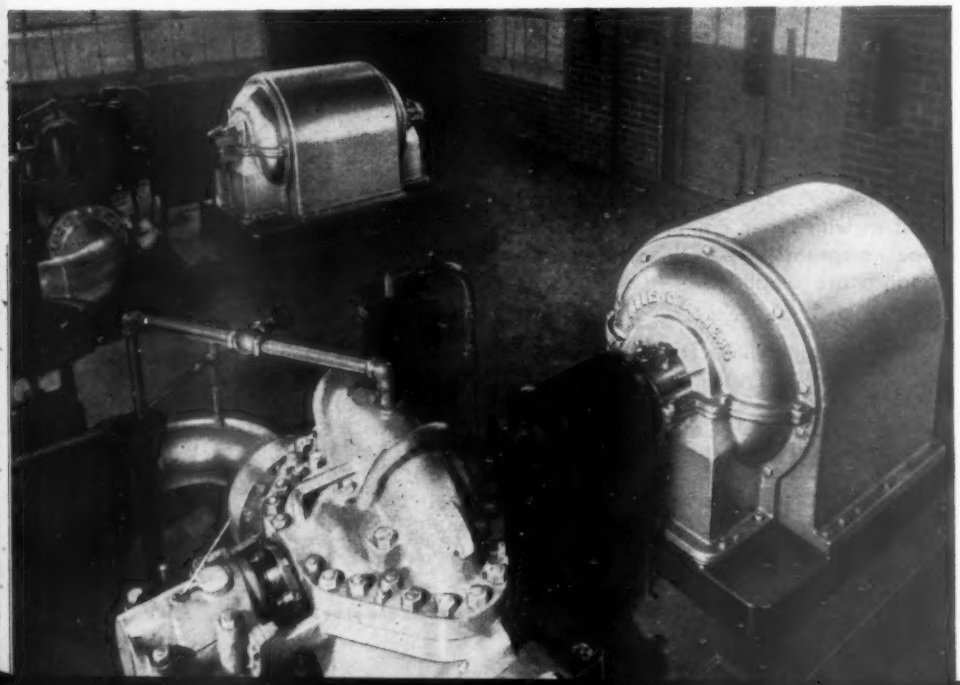
Oil companies have eliminated, as far as practical in their plant layouts, large, expensive building structures that are costly to build and maintain, and have been installing much of their electrical and mechanical equipment outdoors. Today, after the gradual elimination of more and more of the building structure, many types of semi-outdoor and outdoor plants are also operating successfully. This trend, brought about by increasingly high building costs, started in the more temperate parts of the South, and West, and now is finding its way into installations in more rigorous climates.

The weather-protected motor fits in the gap between splash-proof and totally-enclosed. Though developed primarily for steam electric stations, an increasing number of requests for information and quotations from pipe line companies indicates that the weather-protected motor may find numerous applications in this industry.

The weather-protected motor is available above the NEMA 505 frame. Remember, however, that even though better protected than splash-proof designs, the weather-protected motor is still a type of open motor, in that external air passes over the windings. Totally-enclosed fan-cooled motors are better where tough atmospheric conditions exist.

Pipe-Ventilated. Motors may have inlet or outlet openings, or both, connected to pipe or ducts and are then known as pipe-ventilated. In some cases, either the inlet or outlet openings, or both, may be through the base, in which case the motors are known as base-ventilated.

TWO 800 HP, 1770 rpm open-type, ventilated motors driving crude oil pumps.



Totally Enclosed Motors

Totally-enclosed motors are machines so enclosed as to prevent the free exchange of air between the inside and outside of the machine, but not sufficintly enclosed to be termed air-tight.

Standard Totally-Enclosed. As there is no free interchange of air between outside and inside of the enclosure, the totally-enclosed motor is a better motor than any of the open types for most outdoor applications and in atmospheres where dirt, dust, acid, and alkali fumes, salt air and high moisture conditions are present. The enclosure protects the inner working parts. Experience shows that the use of totally-enclosed motors in tough atmospheric conditions results in substantially less down time and lower maintenance costs that with open types.

Trend toward the use of a higher percentage of totally-enclosed motors is constantly increasing. Before World War II totally-enclosed motors represented about 18 per cent of motor unit production of one plant. Today, in that same plant, totally-enclosed motors account for about 50 to 55 per cent, with the remainder being the open types. Some of this increase may be attributable to improved motor designs and to the wide expansions of industries, such as oil, chemical, petrochemical, and paper pulp. Most of the increase can be attributed to the fact that more industries are today using totally-enclosed motors for their applications, recognizing the fact that added protection results in reduced down time, reduced maintenance, and increased motor life.

Explosion-Proof. A gas explosion-proof motor is a totally-enclosed motor built to contain the explosion of gas that may occur within it and to prevent the ignition of gas outside the machine by sparks, flashes, or from the internal explosion.

Dust Explosion-Proof. Dust explosion-proof motors are totally-enclosed motors built to keep the dust out and to prevent the ignition of dust on or outside the machine. Dust, no matter how finely divided, still has physical

THE powerful, dependable Cat* D397 Oilfield Engine above plays a double role for Socony-Vacuum Oil Company, Inc.

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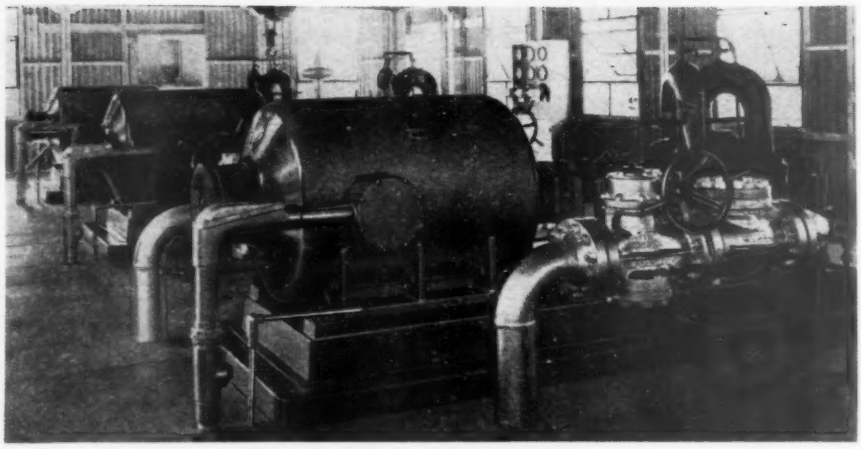

THREE 400 HP, 3600 rpm tube type, totally enclosed, fan-cooled cage motors, used on Texas oil pipe line.

size. It is, therefore, possible to design the motor in such a way to keep the dust outside. Such motors should never be overloaded, nor should any other condition be permitted that would create a temperature in the motor high enough to ignite dust lying on the motor.

Some motor manufacturers design their explosion-proof motors in medium and small sizes so that they meet both the Class 1 Group D hazardous gas requirements, and also the requirements of motors for one or more of the types of hazardous dust atmospheres.

Vertical Motors and Pump Units

Vertical pump units with vertical motor drives have the advantage of small space requirements and less chance of the motor and pump getting out of alignment with each other. Some pipe line engineers hesitate to consider such units, due probably to the comparatively few vertical pumps of large size now being used, and because they are not sure whether the thrust bearings will provide suitably long life. For the information of those considering vertical installations, some fairly large high speed pumps and motors have excellent service records of continuous operation.

Class "A" Insulation

Insulation of motors used by the oil industry is generally class A. If the hottest spot, which occurs somewhere internally adjacent to the insulation, is 105 C, insulation life varies from 8 to 23 years, with 15 years as an average life span. Each 10 C rise in temperature above this 105 C reduces insulation life by approximately 50 per cent. Similarly, a reduction in the hottest spot temperature results in substantially increased life.

These values, though theoretical, were established by tests on insulation and provide reasonable estimates of insulation life. Adverse conditions such as high temperatures, dirt, moisture, oil or grease, acid or alkali fumes on, or coming in contact with, the insulation may seriously effect its life.

The following breakdown of what constitutes this 105 C hottest spot may prove interesting:

	Drip-Proof	Splash-Proof	Totally-Enclosed
Hottest spot	105 C	105 C	105 C
Hot spot correction	—15	—15	—10
Highest observable	90 C	90 C	95 C
Ambient	—40	—40	—40
Permissible rise	50 C	50 C	55 C
Rated temperature rise	—40	—50	—55
Allowance for service factor	10 C	0	0

The hot spot correction is the difference between the hottest internal spot and the highest observable by thermometer, when the thermometer is placed on the winding near the stator core.

Notice that the drip-proof motor has 10 C left over. This temperature safety factor is usually present in general purpose or drip-proof motors, simply to give a margin, because people applying these motors do not always know the load conditions exactly. This 10 C represents the service factor. When a 40 C rise, general purpose motor is operated on nameplate voltage and frequency in an ambient temperature not exceeding 40 C at an altitude not exceeding 3300 ft, the motor can be loaded 15 per cent above its nameplate horsepower rating without reaching a temperature that will cause damage to the insulation. Under such conditions the temperature rise will be closer to 50 C. If the motor is operating in an ambient greater than 40 C, or the voltage and/or frequency are not at nameplate value, do not take advantage of this service factor.

Notice that in the case of the splash-proof and totally-enclosed motor, we have nothing left. These motors, therefore, have no service factor.

Modified versions of class A insulation can be provided on motors to resist adverse conditions such as excessive moisture, acid or alkali fumes, conductive or abrasive ducts, or the so-called "power-house" conditions. These special variations of class A insulation usually consist of additional dips and bakes, or a combination of additional dips and bakes and coatings that resist moisture and the effects of acid and alkali fumes. This treatment is over and above the standard Class A insulation. These modified versions have no affect on the maximum or hottest spot temperatures that class A insulation will withstand.

At best, the extra treatments for these adverse conditions will not prolong the life of the motor to the extent attained by preventing continuous contact of the atmosphere with the motor insulation by use of enclosures, such as totally-enclosed or totally-enclosed fan-cooled features. The slightly higher cost of the enclosed type motor for such adverse conditions will pay dividends in the long run.

Similar examples can be worked out for class B and class H insulation, using the following values:

		Hot spot correction	
	Hottest spot	Open, DP, SP	TE
Class B	130 C	20 C	15 C
Class H	180 C	30 C	25 C

Class B will withstand higher temperatures, and class H much higher temperatures, than class A insulation. These temperatures may result from high ambient temperatures, from overload, or in some cases from building the motor in a frame size smaller than standard.

One pipe line company buys pump units with an impeller of smaller diameter than the maximum that can be installed in the particular pump. Their motors have Class B insulation and the temperature rise rating, based on the enclosure, is the same that it would be if the motor had class A insulation. Then as the capacity and head requirements increase, they can, within limitations, install an impeller of larger diameter and overload the motor.

Heat in a Motor

Heat in a motor results from losses that occur in the machine. The principal losses are:

(a) Friction loss
(b) Windage loss
(c) Core loss
(d) Copper losses on I^2R losses

Though the first three of these losses represent a fairly large proportion of the total losses when the motor operates idle without load, the copper loss accounts for a good proportion of the losses when the motor is operating at, or near, full load. Notice, too, that the copper loss varies as the square of the current. Any condition, therefore, that causes the current to change, affects the heat generated in the motor almost as the square of the current.

Let us consider several conditions that may change the current and heat generated.

Overload. When a motor is overloaded, the current increases almost directly as the load. The amount of heat generated goes up roughly as the square of the current. At 10 per cent overload the current will increase approximately 10 per cent, and the heat will increase about 21 per cent.

Underload. Underload results gen-

erally in currents lower than full load and consequently lowered heat losses. Disadvantages are lowered efficiency and power factor, which may result in the need of power factor correction, or, due to the lowered efficiency, in the consumption of more power than if the motor were designed for the load applied.

Overvoltage. Overvoltage results in decreased copper losses and increased core losses, with the net effect for small values of overvoltage being a reduction in heat. For a 10 per cent increase in voltage over rated, the decrease in temperature rise will be about 3 or 4 C on a 40 C rise motor.

Undervoltage. Undervoltage results in increased current and increased copper losses, and a slight decrease in core losses. For a 10 per cent decrease in voltage below rated, the increase in temperature rise will be about 6 or 7 C on a 40 C rise motor.

Both overvoltage and undervoltage can result in serious heat problems in a motor, particularly if the difference from rated voltage is fairly high.

Unbalanced Voltages. Small amounts of voltage unbalance may result in an excessive increase in current and substantially higher temperatures in the motor. Voltages should be balanced as nearly as can be read on commercial voltmeters.

Other Causes of High Temperatures. High peak loads may cause excessive heating. Long acceleration periods, frequent starts or reversals, and stalling result in very high currents and high temperatures that may cause serious damage to insulation, and even to the rotor construction.

Dirt acts as a blanket and keeps heat in the motor and windings. Motors should be kept clean to prevent the motor from reaching a temperature that may cause damage to the insulation.

Drains and Breathers

A totally-enclosed (or explosion-proof) motor is not air or gas tight. This is clearly brought out in NEMA definitions of totally-enclosed and explosion-proof motors. Even the Underwriters' exacting requirements for totally-enclosed motors recognize that gases and vapors may enter such a machine. Totally-enclosed and explosion-proof motors do, therefore, breathe.

This breathing action is augmented when motors operate intermittently. When a totally-enclosed motor starts and runs, the motor gets warm. Inside air expands and some of that air is forced out of the motor. Then, if it stops for a sufficiently long period of time, the motor cools, inside air contracts, and atmospheric pressure forces outside air into the motor. If this outside air is moist or humid, moist air will get into the motor. The motor may then reach a temperature below the dew point, low enough to cause condensation of some of the moisture contained in the inside air. Repeated occurrences of this type can

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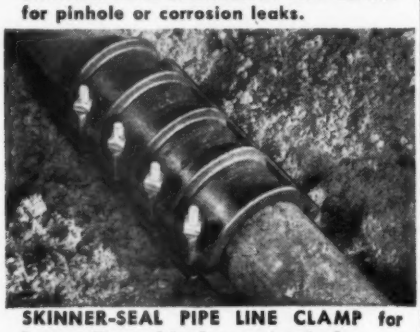

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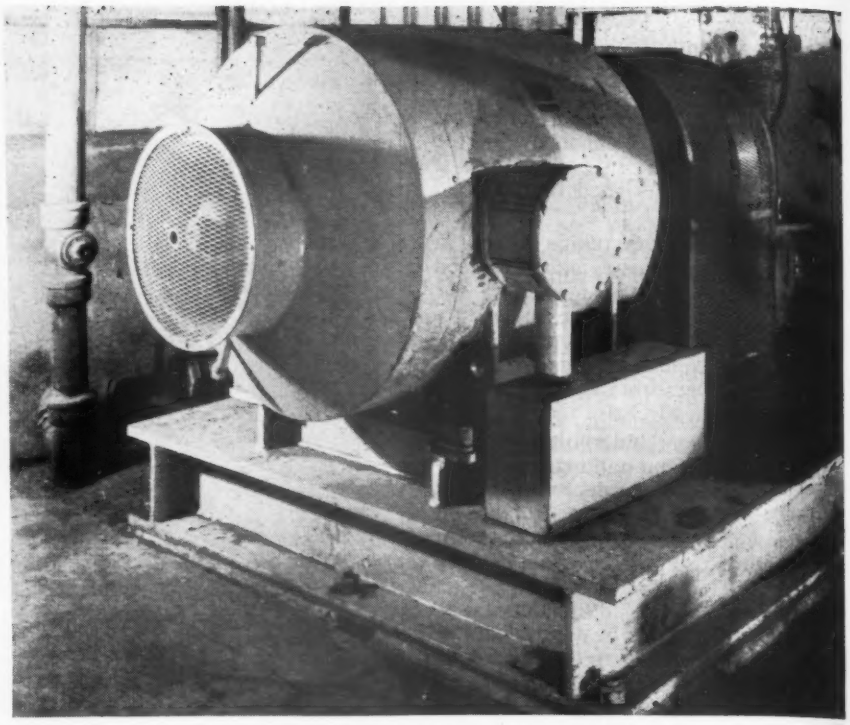

EXPLOSION-PROOF, totally enclosed 200 hp, 1800 rpm motor.

result in an accumulation of moisture in the bottom of the motor.

The most popular method of removing this accumulated moisture is by the installation of a drain in the bottom of the motor frame or in the lowest part of the bearing housing. In "standard," i.e., not explosion-proof, totally-enclosed motors, this drain may be a tapped opening with a pipe plug which can be removed periodically to allow the water to escape. In explosion-proof motors special Underwriters' approved automatic drain valves can be installed at the factory. Such a drain valve is generally installed in a threaded opening; but on explosion-proof motors the installation must be permanent, such as can be obtained by brazing the drain to the motor frame or housing.

Condensation may be less if the enclosure is ventilated. An Underwriters' approved breather, used with the drain, will tend to ventilate the motor to some extent, relieves the condition of moist air flowing through bearing chamber.

Operating practice and knowledge of ambient conditions at the motor installation will determine whether drains and/or breathers are necessary.

If a motor operates 24 hours a day, every day, little or no condensation will occur, and drains and breathers are not required. But, if a motor operates intermittently in a moist atmosphere, drains and/or breathers provide one safeguard against winding failure.

Motor designs, in which the coil ends and connections are somewhat above the inside bottom of the frame, provide a space where some moisture can gather without the windings being immersed immediately in the water.

Space Heaters

Through the breathing action previously described, moist air can get inside a totally-enclosed motor. If the motor is idle for a relatively long period, moisture in the inside air may tend to work its way into and partially impregnate the winding insulation. Such moisture impregnation is more apt to occur in windings where the insulating varnish is relatively old and has undergone some deterioration. But it may also occur to some degree in newly insulated motors. This moisture lowers insulation resistance and may become a problem in high voltage motors.

Space heaters, which are energized automatically through the motor control when the motor is shut down, will keep the inside temperature above the dew point and tend to prevent condensation on the motor windings.

Some oil companies specify space heaters for high voltage motors, usually 100- or 125-hp and larger, for refinery or pipe line installations. A few companies require space heaters on medium size motors of low voltage, but such requirements are rare and usually only for "tough" locations. The compact design of small motors does not permit the installation of space heaters.

Drains can be applied on totally-enclosed or explosion-proof motors of any size. Space heaters can be installed also in medium and larger sizes of drip-proof, splash-proof, weather-protected, and pipe or base-ventilated machines.

The use of space heaters and/or drains is well worth consideration in motors to be installed in moist atmospheres. The additional cost of drains is initial only. For space heaters the additional cost is initial, plus the small cost of power consumption for heating when the motor is shut down. Space heaters may be energized con-

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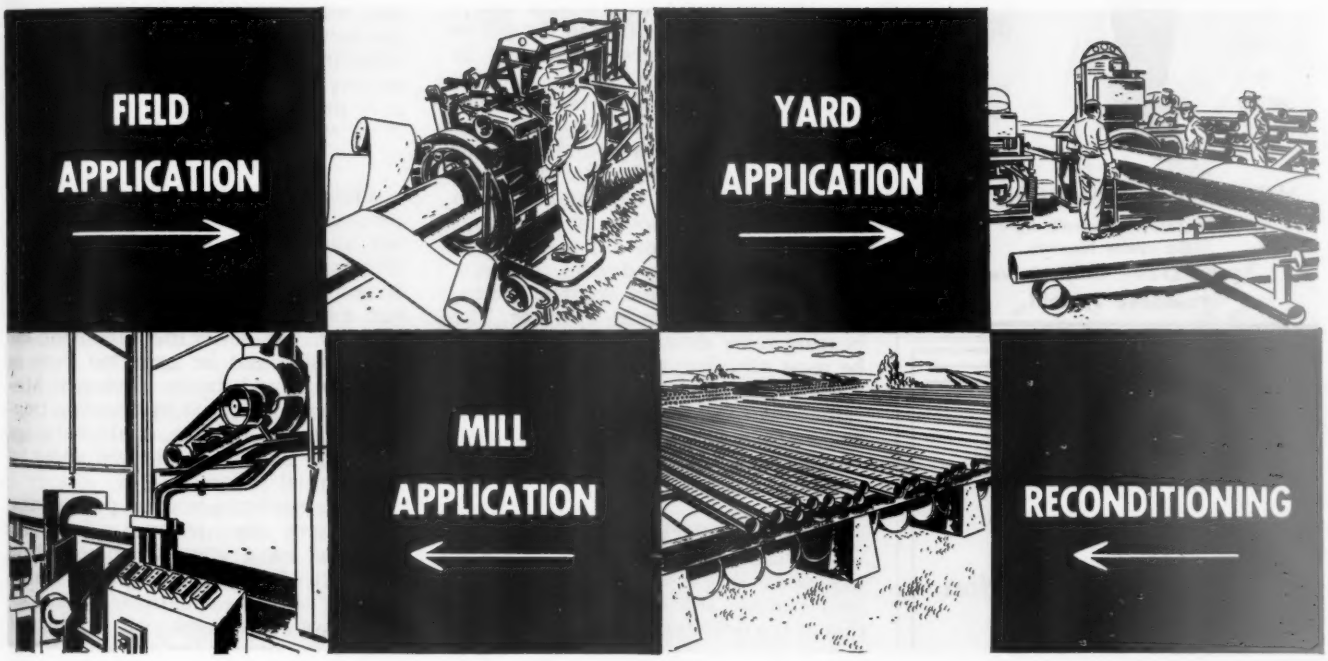

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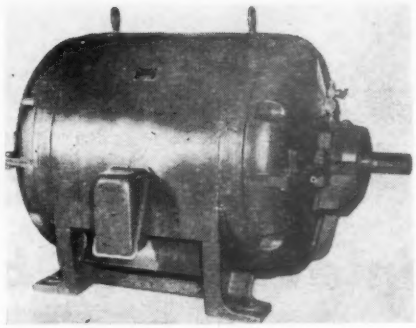


STANDARD 700 hp, 3600 rpm drip-proof motor.

tinuously or occasionally when motors are in storage and, thus, provide winding protection.

Bearing Temperature Protection

Bearing temperature devices are used on some large size, high speed motors with oil lubricated bearings. It has been found that the widest use of motor bearing protection in the petroleum industry occurs on motors in pipe line installations.

Two general types of bearing temperature protection are available. The one type is used with an indicating or recording thermometer. The other type actuates a relay in the control which shuts down the motor if dangerous bearing temperatures are reached.

Both are warning devices for bearing and motor protection. The indicating type depends on an operator. The bearing relay device is automatic. To be most effective, the temperature element must be in the bearing shell, rather than just in the oil well, for the bearing may reach a high temperature before the oil reaches that same temperature.

Stator Temperature Protection

The life of class "A" insulation is halved for every 10 C that the hottest spot exceeds 105 C. If motor protection of the relay type for current limitation is used in the control, the motor may reach high temperatures due to ambient conditions or rather frequent starts, without causing operation of the current relay. If motor protection is of the thermal type, slight overloads may cause some overheating within the limitations of the thermal elements; or the control may be installed in an area where the ambient temperature is higher or lower than at the motor. Thermal elements are affected by the temperature of the element itself, not that of the motor. If the control is in a cooler area than the motor, the motor may reach high temperatures. If the control is in a warmer area than the motor, the control may cause the motor circuit to open below full load.

Embedded detectors, installed in the stator slot beneath the winding, provide a fairly close measurement of stator temperature. Their usage is limited to large motors because they require additional slot depth for themselves and their insulation. One type of embedded detector is for temperature indication; the other, less frequently used, is used in connection with a relay.

A thermostatic device can be installed on or between the end turns of the winding near the stator core. This device may be of the normally open or normally closed type, to close the circuit of a warning light or bell, or to cause a relay to operate and open the main motor circuit. These may be used on motors of almost any size. Their initial cost is much less than that of the embedded detector.

In the petroleum industry, stator temperature protective devices for motors find widest use in pipe line installations.

Pipelining demands continuous operation. Down time is costly. Losses, due to down time, cannot be recovered. Protective devices do not prevent down time caused by motor failure. They do, however, provide some insurance against more serious motor failures, that might result in high repair costs and, more important, in longer loss of production. It is well, therefore, to consider the use of protective devices on motors where continuity of operation is of prime importance.

Alignment

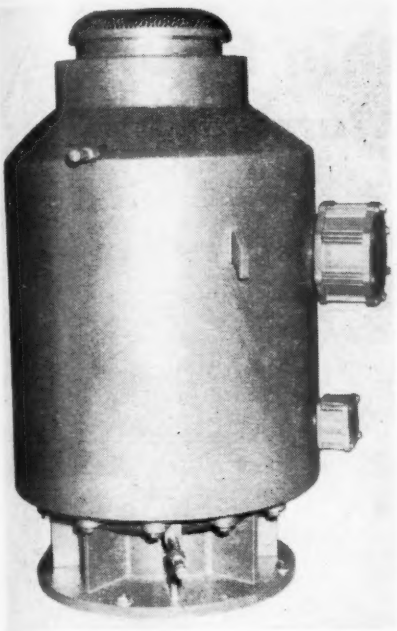
Flexible couplings allow for a slight occasional misalignment of the coupled shafts, parallel and/or angular. Notice that we use the term "a slight occasional misalignment." Remember, a flexible coupling is not a universal joint. The better the alignment, the less trouble can be expected both in the driving and driven machines. Misalignment may result in coupling troubles, bearing failures, shaft breakage and other difficulties brought about by these initial failures.

Some machines, such as pump units, may have the pump and motor mounted on a common base. These units are aligned by the pump manufacturer before shipment. Manufacturers of this type of equipment usually disconnect the coupling before shipment. The machines may get out of line during shipment, or as a result of even slight deformation of the base during installation. It is always good practice to check and, if necessary, correct the alignment after the unit has been installed, but before the coupling is connected and the unit doweled.

Good practice demands that alignment be well within the limits recommended for the motor, the coupling, and the speed of the unit. In general, coupling halves should be aligned within .002-in. total dial indicator reading, *but closer on high speed units*. Remember, the bigger the motor and the higher the speed, the more accurate must be the alignment.

Couplings themselves can usually withstand some amounts of misalignment, either angular or parallel, or both; but misalignment frequently seriously lessens the life of motor bearings and of bearings of the driven machine.

Care must be taken so that end thrust



EXPLOSION-PROOF, totally enclosed vertical motor, 200 hp, 3560 rpm, now in use in pipe-line service.

is not exerted against bearings of horizontal motors, unless the bearings are designed to take such thrust. End thrust on the motor shaft may be caused by the driven machine, by misalignment, or by certain types of couplings. Ball bearings will usually withstand small amounts of thrust without appreciable lessening of bearing life. Sleeve bearings, particularly sleeve bearings of large, high speed motors, are not arranged for such continuous thrust.

If end thrust is exerted on sleeve bearings, so that the shoulder on the shaft rubs the end of the bearing, the bearing may fail. This failure may wear and warp the shaft and wear the bearing sufficiently to permit the rotor to drop until it is rubbing on the stator laminations, creating heat and charring the insulation. Such rubbing may wear away enough of the stator iron to require replacement of the complete stator.

Rotating elements of driven machines usually have very little end play. Large high speed motors with sleeve bearings have a fairly large amount of end play. When a large, high speed, sleeve bearing motor is to be installed, the motor should be so located with respect to the driven unit, and the coupling arranged to limit end float, so that under no condition can the shoulder of the motor shaft come in contact with the end of the sleeve bearing.

A few extra hours spent to obtain proper installation and alignment may save many dollars and eliminate much of the down time that might occur later on.

Horizontal motors with sleeve bearings should be level so that the rotor does not slide "down hill" and cause continuous thrust of the shaft against the end of the bearing.

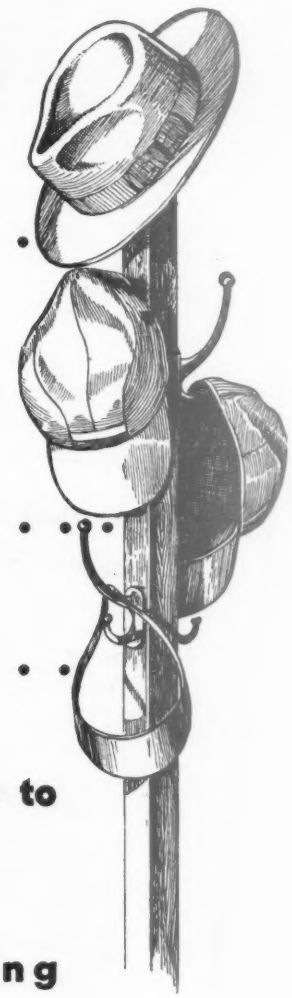
Motors heat up in operation. Heat causes metal parts to expand and raises the motor shaft. This may be just a few thousandths, but sufficient to cause misalignment if the unit was cold when aligned. Similarly, the driven unit may operate at rather hot or cold conditions which may raise or lower the driven shaft. Following the initial alignment at normal temperature, the unit should be run and the coupling halves realigned when the motor and driven unit have been brought to their operating temperatures.

After alignment, but before connecting the coupling, it is desirable to run the motor idle to make sure vibration is not excessive. If excessive, back off foot bolts and check to make sure shims are not arranged to allow motor feet to be pulled out of plane. If necessary, re-shim properly so that feet are in the same plane. Then recheck alignment and vibration.

When alignment is satisfactory, dowel both the motor and driven unit to the base. THIS IS IMPORTANT.

Even though a motor driven unit with flexible coupling may have been perfectly aligned when originally installed and put in service, sagging building structures and expansion and contraction of piping to pump units may distort the driven unit or base, causing misalignment. A periodic check of alignment is advisable. * * *

Abrams



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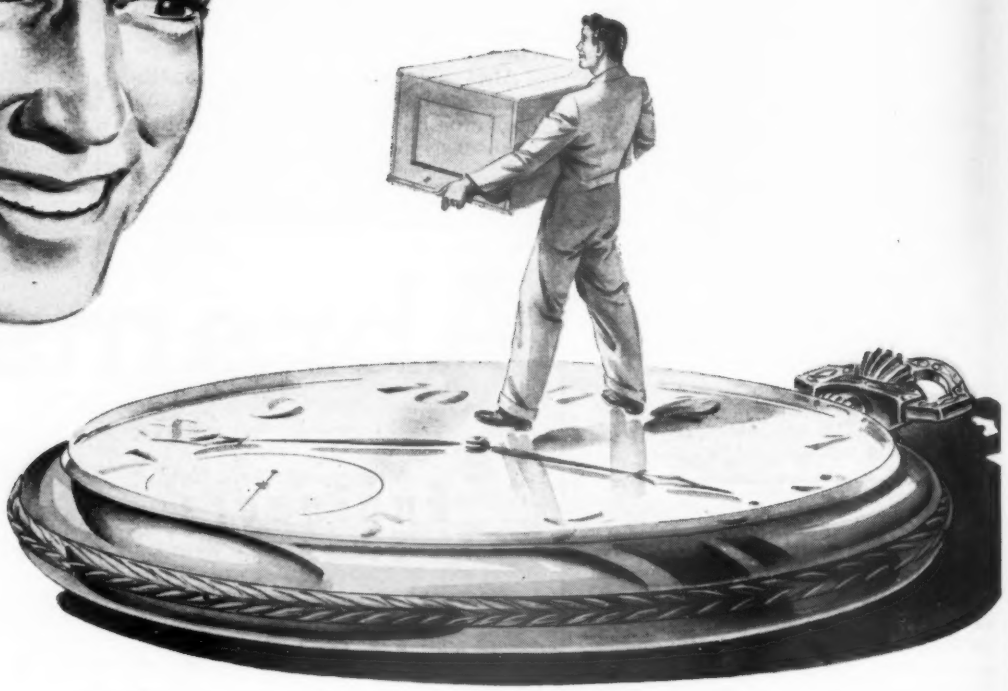

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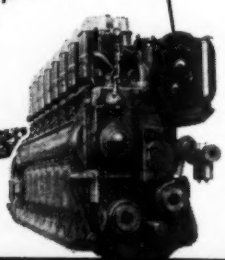

Take the case of this "hurry-up" call from Venezuela, for example—

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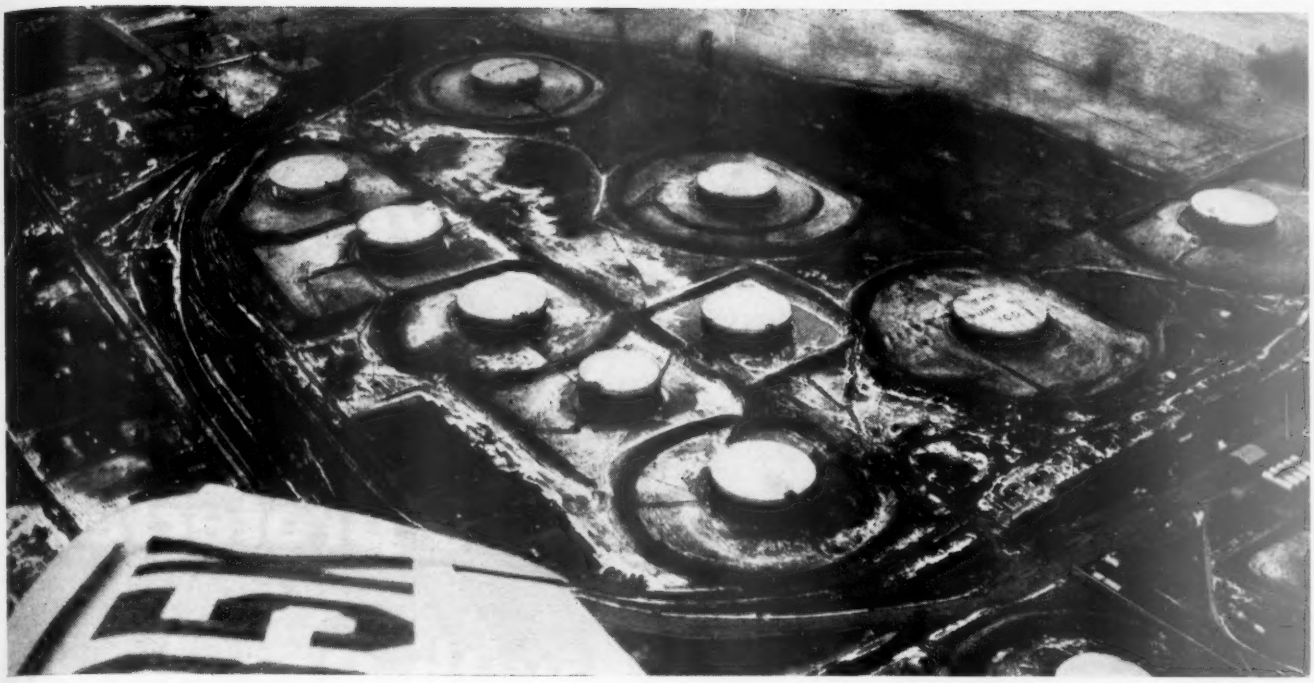

—*Photos Courtesy Motorola NEWSGRAM*

TANK farm and storage tanks used in remote gaging operation.

Ohio Oil Uses

Remote Tank Gaging Via Telemetering

Continuous gaging of deliveries to storage tanks 150 miles away made possible through automatic electronic telemetering over carrier system

D. N. McMILLAN

REMOTE tank level gaging now in use at the Ohio Oil Company's dispatching office at Lima, Ohio, is making it possible to automatically gage tanks 150 miles away.

Crude oil pumped from Ohio Oil's pipe line to Pure Oil Company tanks at Pure's Heath, Ohio, tank farm, must be continuously gaged during deliveries to storage. Installation of electronic equipment to do the job and carry the information to the Lima office 150 miles away has proved effective.

Two sizes of tanks are used for storage at Heath. In one size, a change of oil level of 1 in. represents a volume change of 160 bbl, and a 1-in. change in the other size represents a 148-bbl volume change. Such a large change in volume means not only continuous but accurate gaging is necessary.

Carrier Selected

Communications facilities between Heath and Lima consisted of a wire line owned by Ohio Oil Company. Line, which included no repeaters, had simplexed telegraph signals imposed upon it.

After a search for suitable transmission facilities, installation engineers selected frequency shift audio carrier equipment[1] for the job. While supplying multiplex for the two telemetering signals on the existing wire line, it permitted continued use of voice frequency range. Audio frequency filters enabled the voice currents and audio frequency carrier signals to be separated without mutual interference, while the simplexed telegraph signals were retained.

Gaging Equipment

Liquid level tank measuring gages[2] and measurement and telemetering instruments[3] used in the system were specially selected. The tank level measuring gage consists of an automatic tape reeling mechanism mounted on the side of the tank to be gaged. The tape is passed through a housing and up over the top of the tank to a float within the tank. For telemetering, the tape is

The Author

D. N. McMillan joined Motorola, Inc., in 1951 as carrier and control systems project engineer, and is now bids and quotations engineer for carrier, supervisory control, and telemetering systems. Previous to his association with Motorola, McMillan was associated with the plant and commercial departments of American Telephone & Telegraph Long Lines Department.

McMillan served in the U. S. Army Air Forces from 1943 to 1945 and was graduated from the State University of Iowa in 1949 with a BS degree in electrical engineering.

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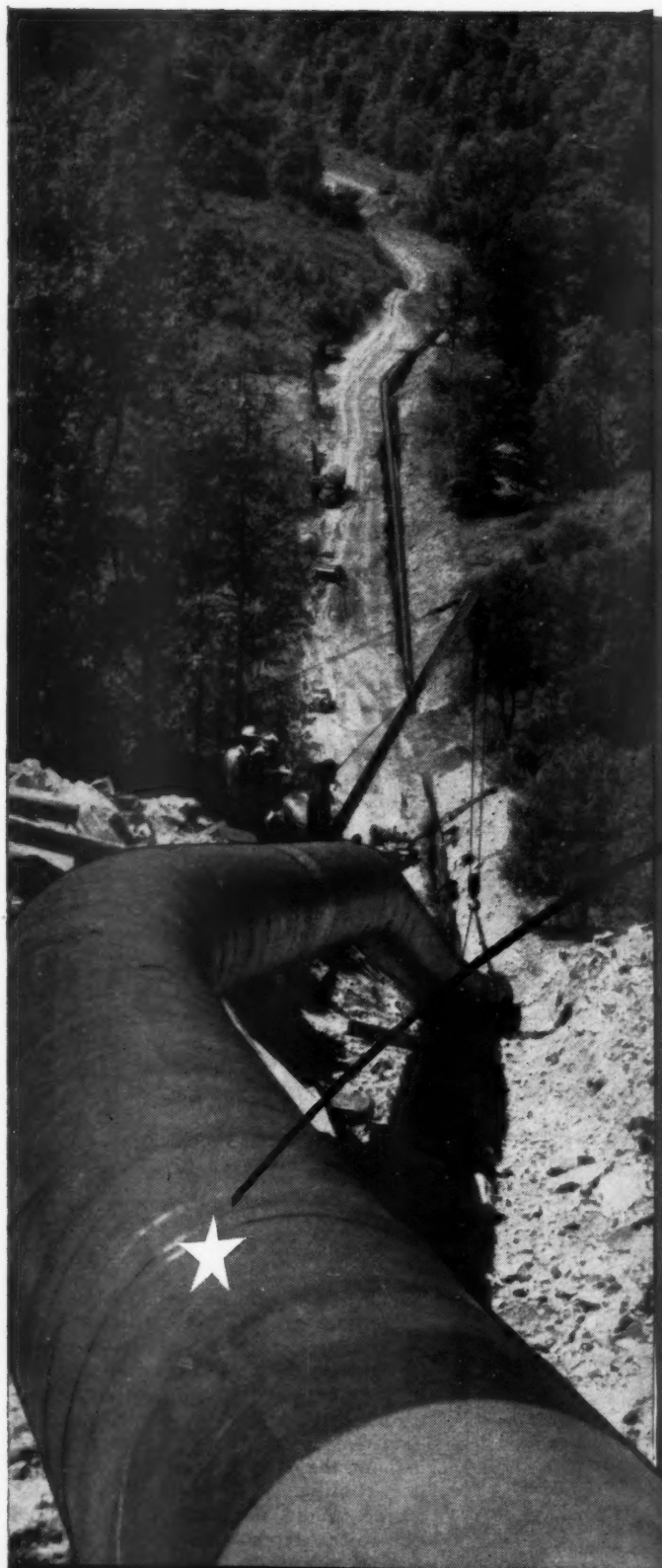

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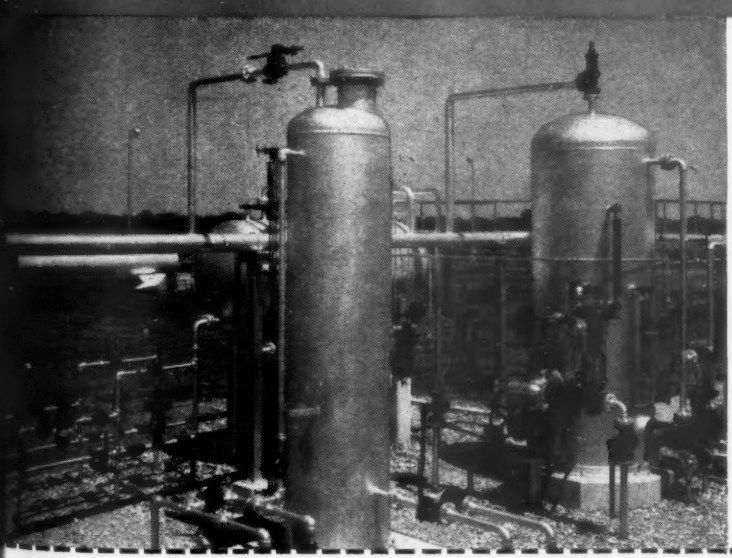

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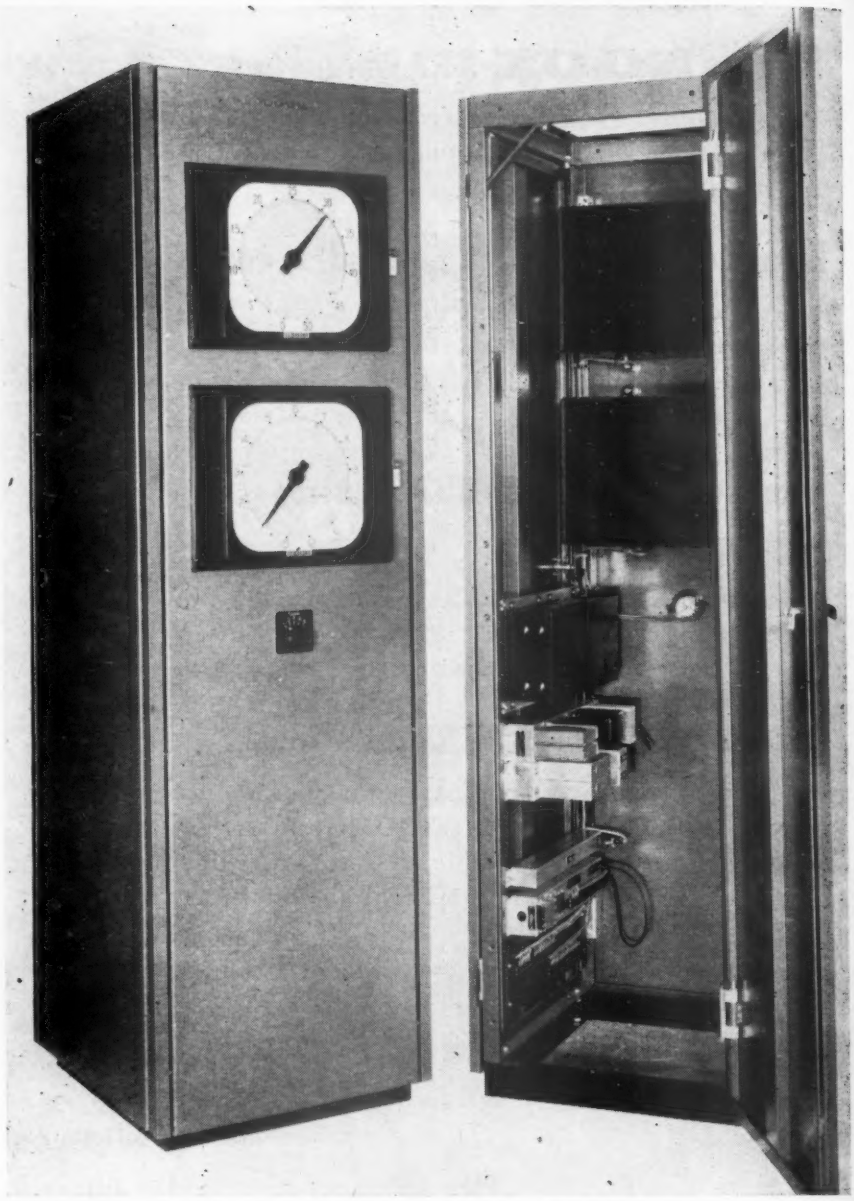


EXTERIOR and interior views of equipment used at dispatcher's office in Lima, Ohio, 150 miles from tank farm.

passed through a sprocket housing having two potentiometers geared to the sprocket.

One of the potentiometers is geared so that its resistance is varied through a complete cycle for a change of one foot in level. The other potentiometer is geared so that its change is proportional to the entire 50-ft height of the tank.

These potentiometers are connected to self-balancing bridge instruments, which have impulse duration telemetering movements geared to the bridge movement. Five second impulse duration signals are keyed by contacts on a transmitter and fed to the audio frequency carrier transmitter.

Carrier Equipment

Audio frequency carrier equipment used in the installation is designed to accept dry-contact keyed signals of the telemeter transmitter, as well as current keyed or sine wave rate signals, converts the impulse information into frequency shift signals in two channels between 2445 and 2655 cycles per second. If additional telemetering channels are desired, three additional channels above the voice band using frequencies up to 3105 cycles per second can be multiplexed.

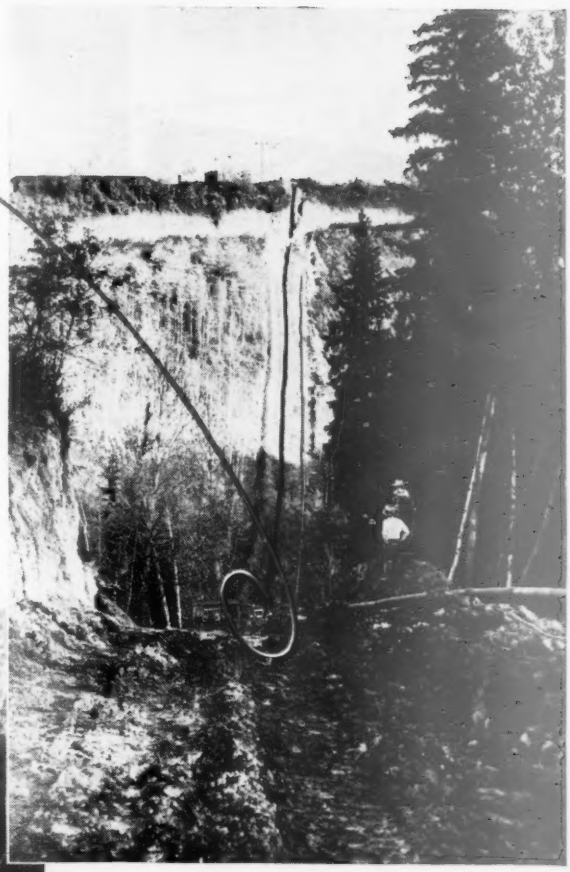
The frequency shift system is particularly adaptable to the transmission of signals on the open wire line available. Wet weather causes trouble with amplitude sensitive systems, whereas such disturbances are less likely to affect the frequency shift audio carrier system.

Maximum wet weather attenuation as calculated for the 150 mile line between Heath and Lima was 10.5 db. This left considerable margin in the AF carrier circuits as full limiting may be obtained on signals as low as -27 dbm and no degradation in performance is experienced even though high amplitude variations and noise levels are encountered.

Performance security of the system

You dig 'em better with the right combination of

Power and Speed



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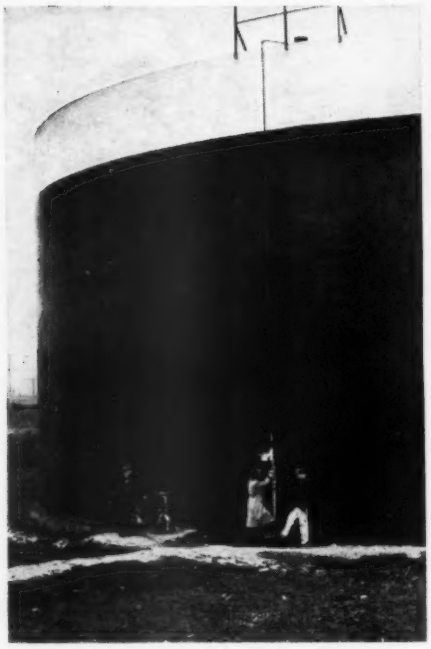
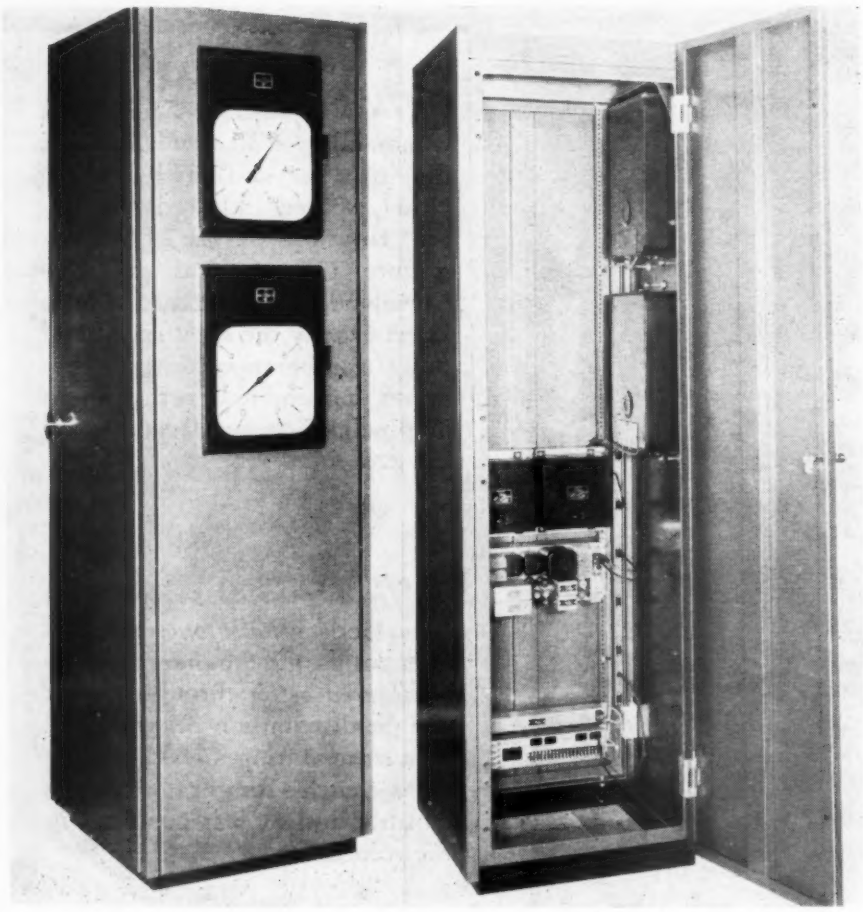


TANK has automatic gaging mechanism installed at side of tank.

TAPE reeling mechanism and potentiometer housing are installed on tank.

EXTERIOR and interior of cabinets housing telemetering equipment used at the Heath, Ohio, location. Selector switch on panel permits selection of tanks.



was demonstrated shortly after the system was installed when one side of the line became grounded during wet weather. Noise level and attenuation on the line became so excessive that telephone communications were interrupted. The telemeter circuits, however, continued to operate.

Although the open wire telephone line provided a suitable medium for the transmission of the audio frequency carrier signals in this case, the carrier equipment may just as well be applied to other audio channels such as those provided by telephone, power line, or microwave carrier equipment. The sub-audio channels provided may be used for the transmission of telegraph or other low frequency signals as well as telemetering.

Use of System

Use of remote telemetering for storage tank levels has proved efficient and economical in this system.

The dispatcher at the Lima office, in communication with the gager at the tank farm, instructs the gager as to which tank he wishes to fill and gage. The gager on duty selects the tank in accordance with the dispatcher's instructions, allowing him to perform other duties without interruption. This, along with elimination of the need for an all-night gager, reduces the station manpower requirement from five to two. The dispatcher's job is also made easier and more efficient as he is able to obtain a continuous reading of the tank level without loss of accuracy. Telephone contact with the gager also allows the dispatcher to check any irregularities in filling of the tank that he might note from his telemeter readings.

In the event such information is desired, a continuous record of the readings can be automatically obtained by recording instruments.

[1]Motorola AF Carrier
[2]Shand and Jurs gages
[3]Bristol Dynamaster and Metameter units

* * *

Washington Line Complete

Completion of a $4,000,000 petroleum products pipe line from Pasco, Washington, to Spokane was announced by T. S. Petersen, president of the Standard Oil Company of California. The new line, constructed and to be operated by Salt Lake Pipe Line Company, common-carrier subsidiary of Standard, is part of a $48,000,000 oil supply system developed by Standard and its subsidiaries to serve the Intermountain and Inland Empire areas.

The system includes $21,000,000 in pipe line facilities from Salt Lake City through Boise to Pasco; a $16,000,000 refinery at Salt Lake, and a $7,000,000 crude oil pipe line supplying the refinery from Rangely field in Colorado.

Input of the Pasco-Spokane link will be supplied by the company's pipe line net from Salt Lake. Occasional barge loads shipped up the Columbia River also will be delivered to the new line. Approximately 140 miles in length, the Pasco-Spokane line is 8 in. in diameter and will have a through-put capacity of 15,000 bbl a day. Principal products to be carried are gasolines, heating oils and diesel fuels.

In announcing the new line, Peterson stated:

"Completion of this new line will give the Spokane area better service and will further assure the supply of vital petroleum products to customers in the Inland Empire." He added that this was the first pipe line built to serve the people of the Spokane area.

..designed specifically for your requirements!

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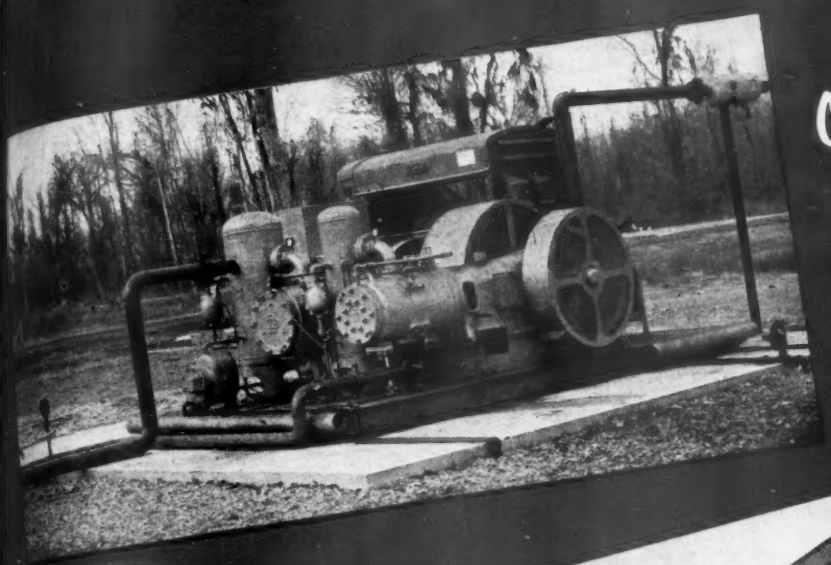

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P 625.391.

Public Need Not Fear Gas Lines

There has been considerable apprehension but transmission systems, in design and operation, have been as safe as human ingenuity can make them

STANLEY OWENS*

PROTECTION of the public against property damage and personal injury is foremost in the minds of those engineers and others charged with the responsibility of planning, designing, constructing, testing, and operating a modern electric welded large diameter natural gas pipe line. Contrary to popular misconception, the transmission of natural gas at 800 psig is a common and ordinary practice. Gas is handled and processed by refineries and similar companies at pressures as high as 6000 psig. Many such plants have been operated during their entire existence without a single failure or accident.

Gas transmission pipe lines today have a total mileage exceeding by far that of the combined mileage of all of the American railroads. Building and operation of gas pipe lines has become commonplace for many years in the great Southwestern section of our country.

With the advent of the piping of natural gas into urban areas that have never had its advantages, there has been some concern by the residents over the relative safety of natural gas.

This fear, without basis, has extended to engineers and members of the legal profession in these regions where natural gas is being pioneered.

Natural gas pipe lines or transmission lines are designed from the beginning to be as safe as human ingenuity can make them.

Pipe Production Safety

Attention to safety begins in the steel mills where special alloy steels have been developed for fabrication. A ladle analysis is made on each heat of steel at the mill. Only plates from those heats conforming to the contract ladle analysis are used.

Tensile tests also were conducted on specimens cut from one length of finished pipe made from a plate selected from each heat of steel. A transverse tensile test is made on a specimen cut from a finished pipe across the weld with the weld in the center of the specimen, to determine the ultimate strength of the weld.

After the rolling of the plate a physical inspection is made for gage, flaws, and defects.

Pipe is then double-welded by a submerged arc fusion welding process (both internally and externally). Each weld is inspected, both on the outside and inside at the mill. In addition, an X-ray control is used in the welding procedure at the mill.

Each length of pipe is then placed in a retaining die and subjected to an internal hydrostatic pressure to increase the initial yield point and expand the pipe to the specified outside diameter. Comparative tensile tests show that the yield strength of the steel is increased by 12,000 to 20,000 psi by the internal expanding or cold working operation.

Hydrostatic Tests

Following the expanding operation, and with the same equipment, the retaining die is removed and a specified hydrostatic pressure test made. Each length is tested to a hydrostatic pressure that will produce a stress of 90 per cent of the actual transverse yield strength as determined for each particular heat. Pressure test varies according to the thickness and the diameter of the pipe. On 30-in. by 0.3125-in. size pipe, a pressure test of 975 psi is applied. Test pressure is maintained for not less than 10 seconds.

For the determination of the pressure to be applied at the mill on the 30-in. by 0.3125 size pipe, Barlow's Formula is used:

$$P = \frac{2 \times t \times S \times 90\%}{D}$$

Where:

P = pressure, psi.
t = wall thickness of pipe, in.
S = minimum yield, psi.
D = outside diameter of pipe, in.

Then, substituting we have:

$$P = \frac{2 \times 0.3125 \times 90\% \times 52{,}000}{30}$$

$$P = 975 \text{ psi.}$$

While under pressure, pipe length is further tested by being struck 10 blows with 6-lb hammers, each approximately 24-in. apart along the entire length of longitudinal weld.

Each pipe joint is then mill inspected for flaws, defects, circumferential tolerance, end finish or bevel, and gage.

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Engineering Inspection

Each joint of pipe is then examined by inspectors from an independent firm of engineers. These inspectors examine each joint of pipe both externally and internally and their findings insure confirmation to specifications.

Upon arrival at the railhead, the pipe is inspected while being unloaded, for possible damage en route.

A further inspection is made during the double-jointing welding procedure, which is followed on each spread.

When the pipe is strung in the field, each joint is examined for any damage that might have been caused in transit, unloading, stringing, or while stored on the right-of-way.

Welding Operations

Before being permitted to weld on the pipe line, all welders have to pass a qualifying test for high pressure electric welding. All field welding operations are inspected by qualified welding inspectors who have successfully passed all welding tests themselves.

Each welder is equipped with an identifying stencil with which he marks each weld as completed. This identifies a welder in the event a weld fails to pass inspection.

Through visual inspection or X-ray determination, a welding inspector has the authority to remove any weld from the pipe line. Such welds are tested and for each that does not test beyond the yield of the steel or otherwise shows imperfections below standards, such as gas pockets, slag inclusions, lack of penetration and for ductility, the identified welder is removed from further welding on the pipe line.

Frequently test welds are cut from the pipe line and tested to determine the running quality of the field welds. Visual inspection of girth welds is augmented by X-ray photographs. These tests are made by operators employed by independent X-ray engineers.

The type of welding rod selected is designed to fit the metallurgy of the pipe to develop tensile strength and ductility above the physical properties of the parent metal in the pipe line.

Following the welding procedure, the pipe is then cleaned, primed, and coated with a coal tar high melting point

*Director of Safety, Transcontinental Gas Pipe Line Corporation.

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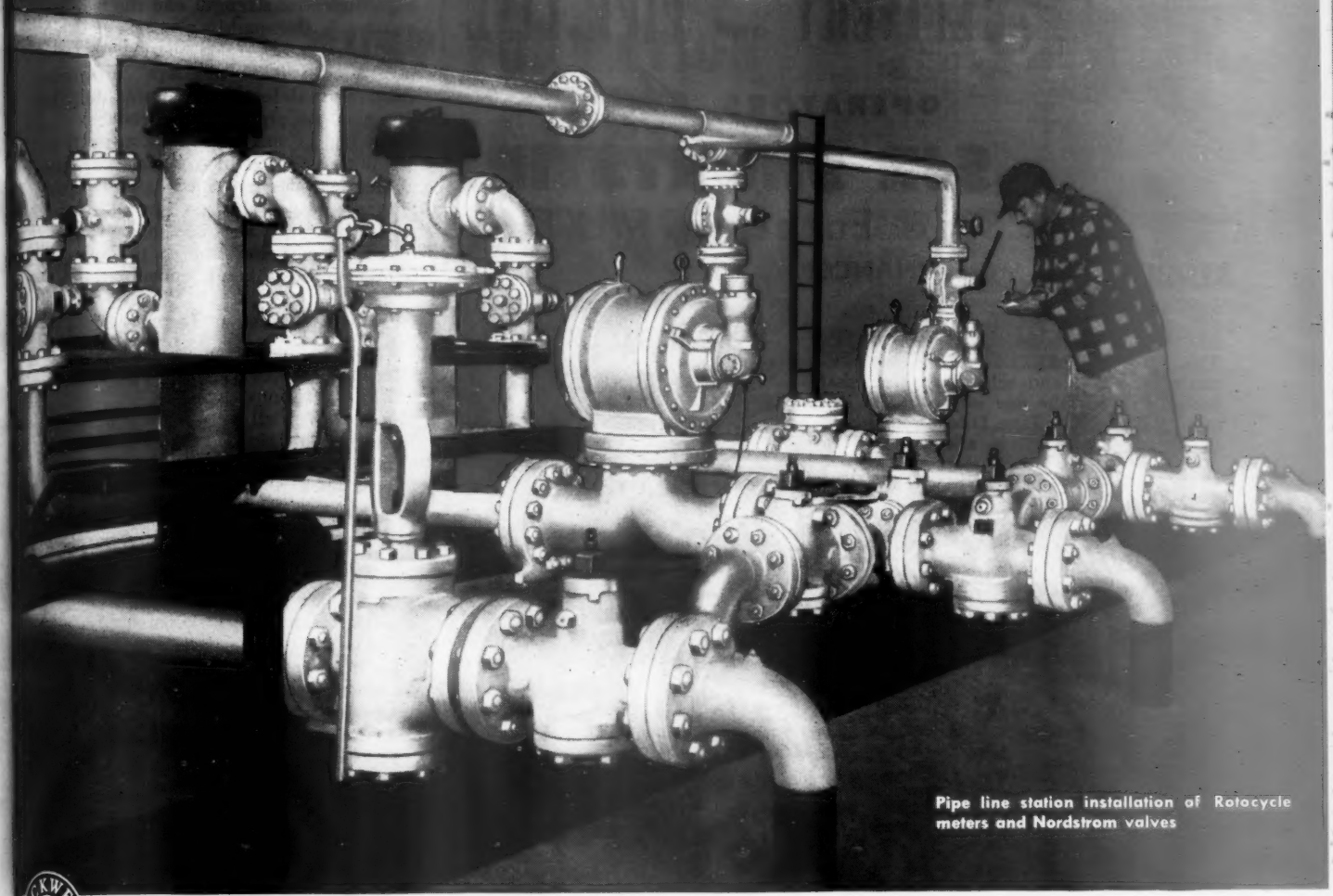

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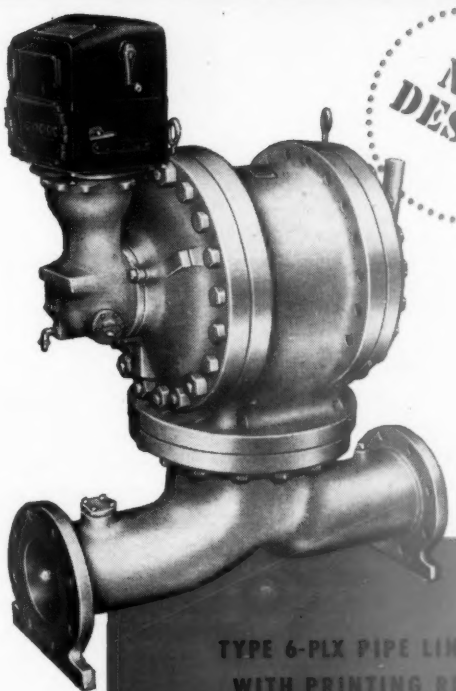

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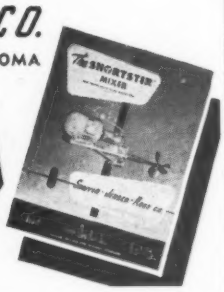

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enamel impregnated with reinforced glass fiber. The materials used have a high dielectric strength and the finished coating is thoroughly checked with an electric detection to determine the presence of any "holidays" or voids. Such minor defects are repaired prior to lowering the pipe into the trench.

Studies of soil conditions as well as the presence of strong electric currents guide the installation of cathodic protection equipment. Test leads are installed at intervals of one mile to facilitate frequent checking of the electrolytic conditions being encountered.

Pressure Tests

Prior to operation, the completed pipe line is tested in short sections. The testing operations include:

Removal of all air in the pipe by a complete purging operation during which natural gas, at low pressure, is forced through the section of the line under test.

A pipe line cleaning device is then run through each section. This removes iron oxides, dirt, debris, liquids, or any other foreign bodies that may have entered the line during construction operations.

Each of the above tests is conducted incrementally in several stages and the section under test is carefully checked and inspected after each stage.

Block or shut-off valves are installed at frequent intervals for the purpose of isolating any particular section of the pipe line.

The main line valves are of the plug type, which insure a positive shut-off in a minimum space of time.

Each valve is carefully tested after installation. The valve is then securely locked in its operating position.

The line is tested to a pressure of 50 psi over the maximum operating pressure for a 24-hour period.

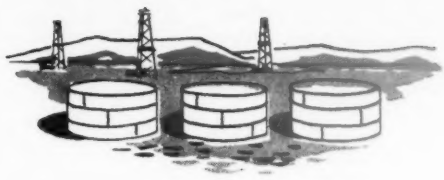
During the entire testing procedure persons living along the right-of-way are kept continuously appraised of the testing operations by individual and personal contact with each person or head of a family group residing or working within a distance of 500 ft on either side of the pipe line.

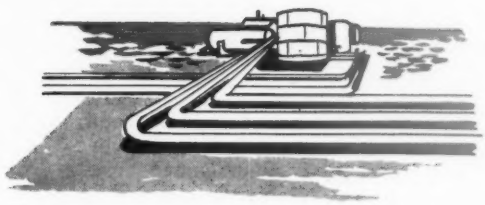
At no time is a test pressure applied until the "all clear" has been given to the testing crews by the employees responsible for the notification procedure.

Operating Safety Methods

The pipe line system is staffed with maintenance crews situated at frequent intervals along the line. At these locations are stored the equipment, trucks, cranes, hoists, tractors, cutting and welding units, length of pipe, fittings, valves, and other materials necessary to maintain the line and to meet any emergency. Duties of the maintenance crews are to maintain the pipe line in a safe and stable operation on a 24-hour basis. Each crew is equipped with mobile radio equipment installed on its trucks, which enables it to be in constant two-way communication with the compressor stations, the central dis-

PREVENTS CORROSION AND RUST FORMATION IN STORAGE TANKS, PRODUCTS PIPE LINES AND TANKERS





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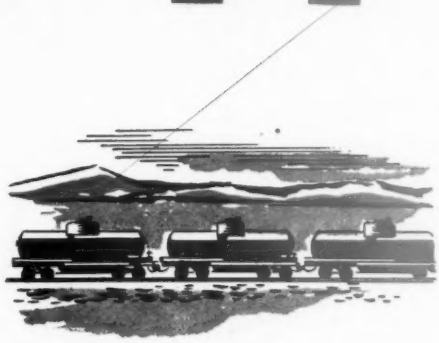
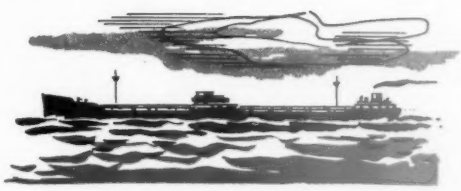


Kontol 77 prevents corrosion and rust formation in facilities for handling finished products. It is an oil-soluble organic inhibitor, and can be used effectively in the prevention of corrosion in products lines, tankers and storage tanks.

Extensive research and commercial usage have proved Kontol 77 to be an effective preventive of rusting caused by the presence of oxygen in finished petroleum products. Using A.S.T.M. Test No. D-665, aviation gasoline was rendered non-rusting when inhibited with only 3 parts per million of Kontol 77.

Kontol 77 has no harmful effects on product quality. For example 100/130 octane gasoline, treated with 14 p.p.m. shows no change in color, octane number, accelerated gum, precipitated lead or other av-gas specifications.



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A complete pressure control system is utilized throughout the pipe line system and at no compressor station can the discharge pressure exceed the maximum operating pressure of 800 psi. This pressure is further automatically controlled by the pre-set blow-off or safety valves at each compressor station.

Each compressor station is equipped with an emergency shut-down switch, which enables the entire station to be isolated from the line in a matter of some 47 seconds. Switches are of the fire alarm telegraph type. A handle projects from the end of the switch and must be turned against a spring tension to operate. The switch, mounted on a pedestal, is situated near the entrance to the parking lot. This is the point at which all employees would normally pass when leaving the station.

In the event of an emergency, if the employees are forced to leave the station, the majority of them would normally pass the location of this emergency switch, any one of whom could set it in operation.

When the handle is turned, it actuates a series of electrical circuits that immediately shut off the rectox units supplying the power to the ignition on the compressor engines, thus shutting off the flow of gas through the compressors. It actuates a switch that closes on a circuit supplying power to the electric motor-driven valve mechanism on the side gate suction valve, closing off the intake gas to the station.

It also closes a circuit that operates the electric motor-driven discharge valve for the station, closing this valve. This action effectually isolates the station and cuts off any source of gas from the main line.

Safety Record

Transcontinental's natural gas pipe line and its operations extend 1840 miles from Mercedes, Texas, to 134th Street, New York City. Including sales and purchase laterals, the system contains a total of 2330 miles. The major portion of the line is 30-in. in diameter. Nineteen compressor stations maintain the pressure and provide a maximum volume.

Following acceptance from the contractor, the Transcontinental line was placed into operation approximately two and one-half years ago.

From the inception date of operations not a single accident involving injury to the public or damage to public property (excepting automobile accidents) has occurred.

One big question looms, however: What type of accidents involving the public are inherent to the operation of these pipe lines?

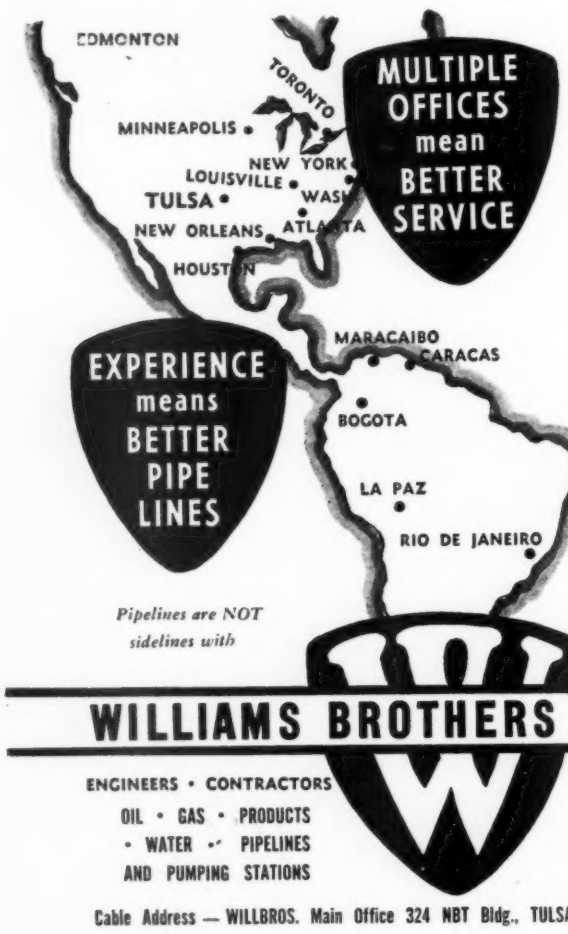
At a recent meeting of the Natural Gas Transmission Safety Association, each of the member companies was polled as to the most frequent, costly, and outstanding hazard as reflected by his safety records. Surprisingly the answer was unanimous: Automobile and truck accidents occurring on the public highway and remote from the pipe line. These, of course, were not due to an inherent hazard of the pipe line operation.

The average piece of right-of-way crossed by the line approximates ⅛ of a mile in length. Assuming a failure that might possibly involve some material damage to a landowner, the chance of a repetition of the failure on any ⅛-mile section (based on experience to date), will be once in (1840 miles × 8 miles × 2½ years, divided by 2 for the average:) 18,400 years.

Conclusion

Properly designed, well constructed, and well managed large diameter natural gas pipe line systems are a contribution to the safety of the public living along its right-of-way.

This is proved by the record of continuity of service of those lines that are modernly engineered and especially designed and built for the purpose of transmitting high pressure gas over long distances. With a record of practically 100 per cent of continuity of service behind them, these lines have reduced to a minimum the possibility of damage to public property or personal injury to the public. ★ ★ ★



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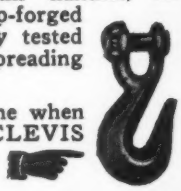

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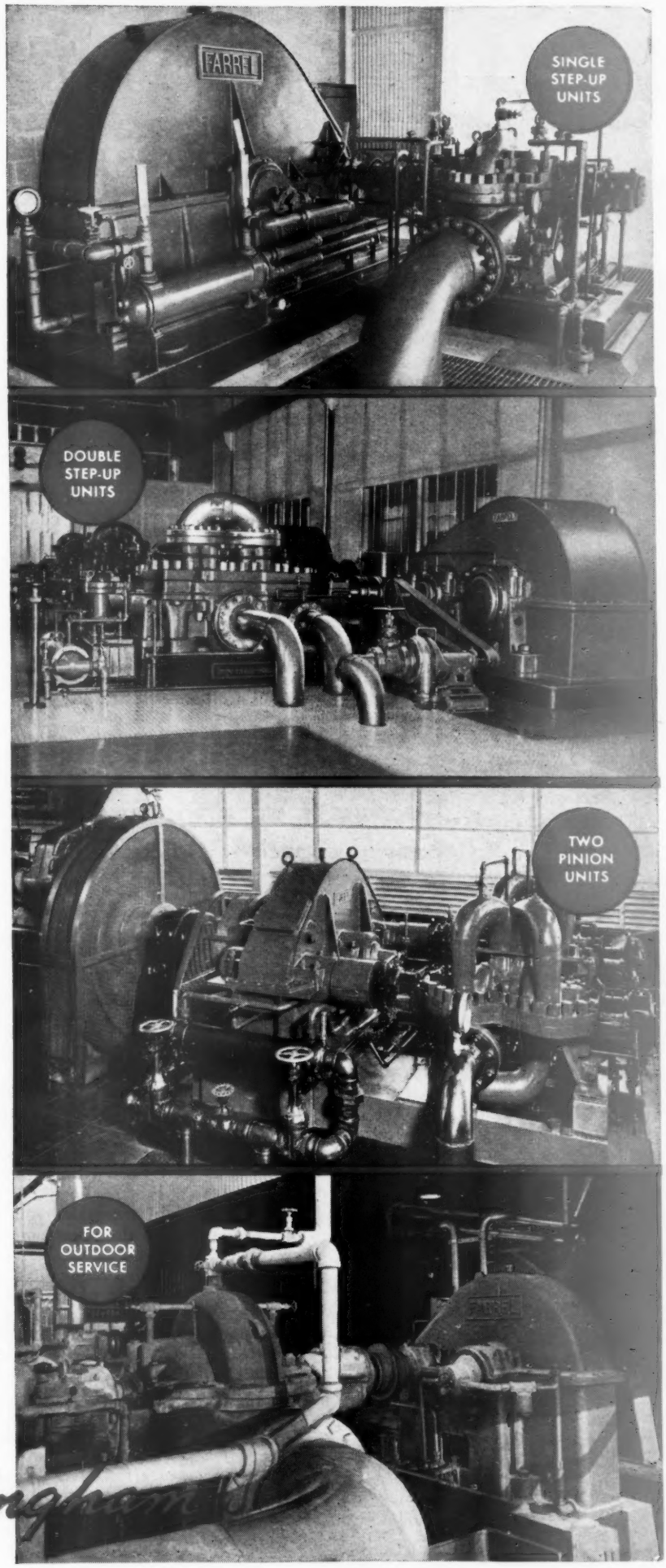

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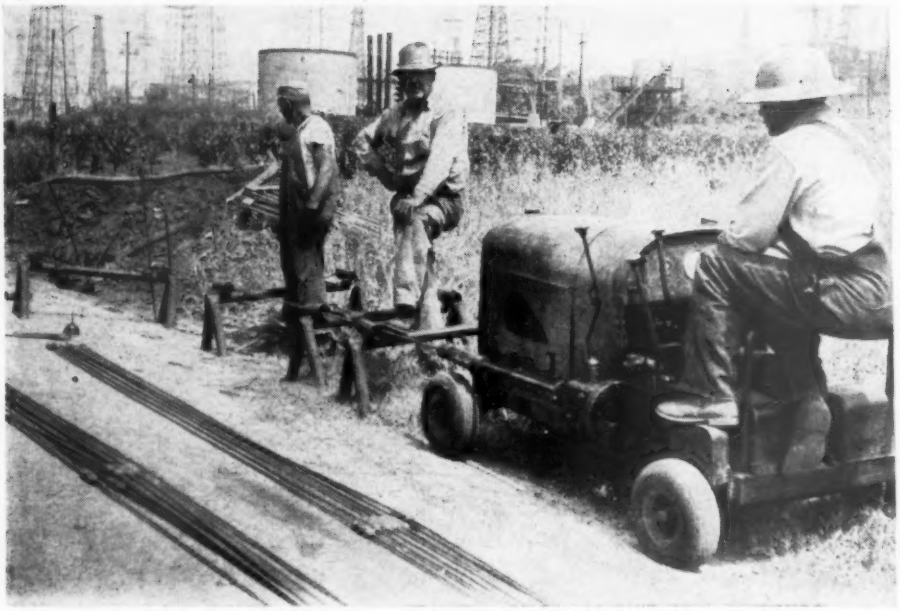


Power drive and rods.

Waste water line after five years.

Cleaning of In-Place Pipes

Cleaning of older pipe lines is answer to reduced carrying capacity; methods are economical, efficient

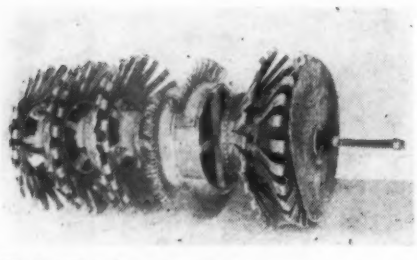
GEORGE ELLIS*

ECONOMIES made possible by cleaning pipe lines rather than replacing them have only recently been impressed upon industry. The awareness of the benefits that could be obtained gained strong impetus during the war when new pipe was virtually non-existent. Now the advantages of what once was an emergency measure have been so thoroughly demonstrated that few companies would consider replacing old pipe lines whose only fault lay in a reduced carrying capacity.

The carrying capacity of pipe lines may be impaired, or, in extreme cases, completely lost for many reasons. There are three principal methods for correcting these conditions: (1) The use of chemicals, (2) mechanical cleaning, and (3) interior lining of pipe combined with mechanical cleaning. In many cases the first is eliminated because of economical and physical disadvantages. The second may be resolved into two classifications: Hydraulic and power cleaning. The third method is highly recommended for the treatment and prevention of corrosion.

Mechanical cleaning returns to service more than 95 per cent of the carrying capacity of new pipe and costs are but a fraction of the cost of new pipe. These costs can generally be considered about 1/30th the cost of new pipe installed.

*Flexible Pipe Cleaning Company.



Hydraulic line scraper.

Hydraulic Cleaning

Most hydraulic tools are similar in construction, differing mainly in cutter blade design and arrangement. In Fig. 1 is a typical tool showing the arrangement and blade design as well as the "pusher." The operational procedure generally followed is that the tool is drawn into a spool and the spool returned to its place in the line. The line is sealed and fluid is applied at the correct volume and pressure to give the tool the required rate of travel. A sufficient amount of fluid is allowed to bypass the rubber "pusher" and carry away the foreign material scraped from the pipe. The tool usually emerges in an open hole, ditch, etc. A rate of travel of about 125 fpm seems to give the best results in cast-iron or welded steel pipe, whereas about 80 fpm is used in riveted steel pipe.

The hydraulic gradient, thickness, and hardness of the foreign material determines the hydraulic force necessary to move the tool and also the feasibility of this method.

For example: A pressure of 5 psi was used to move through 3092 ft of 30-in. CIP salt water cooling intake line in 16 min; 26½-cu ft of a mineral salt water scale was removed from 6.7 miles of 8-in. CIP waste water line in 2 hr and 40 min with a maximum working pressure of 65 psi; more than 40,000

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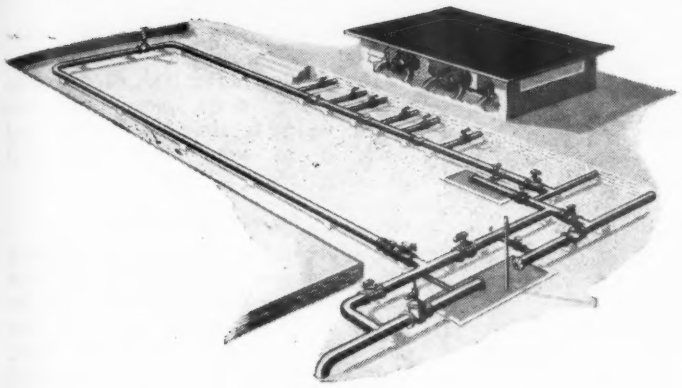

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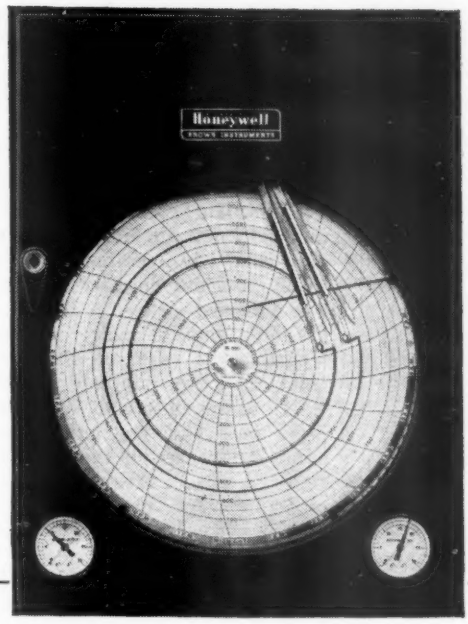

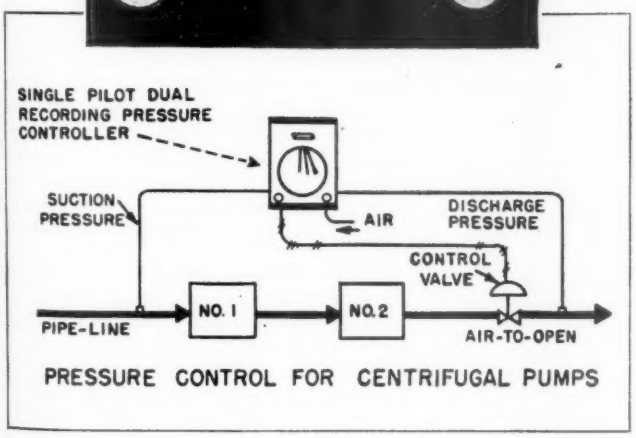

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ft of 6-in. line was cleaned of a wax deposit.

The greatest advantage of hydraulic cleaning lies in its linear range and speed, which is almost unlimited, and its ability to round bends. Because of its range, costs are low.

Power Cleaning

This method employs the use of spring steel rods rotated by a motor, which at the same time drives the tool into the line. It is similar to drilling except that it is carried out in a horizontal plane. Numerous types of tools can be placed on the lead rod depending on the foreign material found in the line. The speed of rotation as well as the horizontal speed can be regulated but usually runs at 500 rpm and 5 ft per minute.

This method depends upon fluid to carry the cuttings out of the line.

As much as 2000 ft of pipe has been cleaned in 8 hr with the power drive. In Fig. 2 is shown the power drive and rods in action. Fig. 3 shows an 8-in. waste water line that was cleaned after only 5 years' service.

Main advantage of power cleaning lies in the fact that type of pipe, diameter (pipe size can run from ¾-in. to 14-ft in diam), foreign material present, and thickness do not cause much concern except in deciding the type of tool to be used and the best speed combination involved.

Limitations of power cleaning are length of run (average distance cleaned from one clean out hole is 1500 ft for smaller pipe and about 900 ft for larger pipes in 8 hr), restrictions caused by bends (depends on type, size of pipe, and radius of curve), and location of pipe (whether overhead, stalked, or depth of cover).

Summary

In this article have been presented some aspects on cleaning, from an economical viewpoint, to show some of its advantages and disadvantages, and the general methods employed in the petroleum industry. Mechanical cleaning followed by intelligent treatment or maintenance offers the best solution for most existing problems. * * *

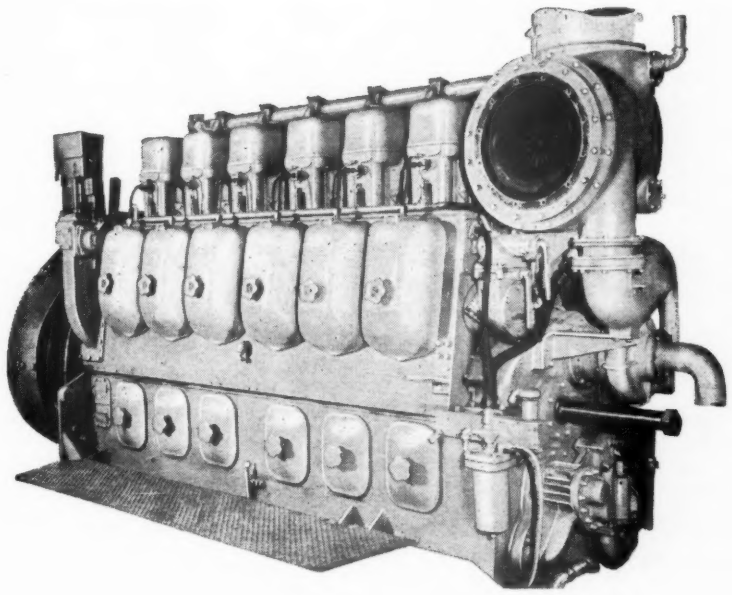
A midwest oil pipe line has been operated by remote control from New York City for almost two years. By metering and teletype facilities, the New York operator has a complete picture of, and full control over, the eight-inch pipe line which connects two points several hundred miles apart. In an emergency, the operator can sound a siren in each of the pumping stations to alert the local operator on duty. Progressive, up-to-the-minute operations like this are constantly being developed by the oil industry to speed the process of bringing petroleum and petroleum products to the consumer.

Presenting...

the heavy-duty, lightweight

ALCO 251-A

all-purpose diesel engine



ALCO 251-A SPECIFICATIONS

Size: 6-cylinder
Bore: 9″
Stroke: 10½″
Cycles: 4 turbocharged
Horsepower: 690
Rpm: 900
Net weight (engine only):
21,350 lb dry;
22,500 lb wet

TYPICAL APPLICATIONS

Oil-well drilling rigs
Crude oil pipeline pumping
Products pipeline pumping
Gas pipeline pumping
Electric power generation
Irrigation pumping
Dredging
Portable units mounted on skids, trailers, rail cars

The Alco Model 251-A—an in-line, 9 x 10½-in. diesel engine designed for a variety of stationary or portable uses in continuous or standby service—incorporates Alco engineering and experience gained in the manufacture of the famed "244" V-12 and V-16 engines of the same bore and stroke. The 251-A combines heavy-duty output with light weight, ease of maintenance, and low operating costs.

Special Features Include:

★ Engine base and frame of structural steel—lighter weight permits lighter, more economical foundations.

★ Compact design (11 ft 5 in. long, 4 ft 11 in. wide)—saves floor space.

★ All wearing parts easily accessible.

★ Lube oil sump, pump, cooler and strainers, and circulating water pump, are integral parts of engine—for low installation cost.

★ Arranged for Dual Fuel by *adding* parts—not by replacing parts or rebuilding engine.

★ Started by air motor, on as little as 60 lb air.

★ Free end has extension driveshaft for auxiliaries (radiator fan, air compressor, etc.).

Additional details are given in Bulletin DE-2, which your nearest Alco sales representative will be happy to send you, along with complete information in terms of your own specific requirements. Contact him at New York, Beaumont, Chicago, Cleveland, Houston, Kansas City, San Francisco, Schenectady or St. Louis.

Alco THE MARK OF MODERN ENGINEERING

ALCO DIESELS

AMERICAN LOCOMOTIVE COMPANY
SCHENECTADY, N. Y.

1850-hp Simple Cycle

Gas Turbine On Mississippi Line†

Mississippi River Fuel Corporation reports on three years' experience operating first natural gas line unit

G. CARL COOPER, JR.*

IN the spring of 1949 a turbine compressor unit was installed at Wilmar, Arkansas, as an experiment on the 425 psi transmission line of the Mississippi River Fuel Corporation's system. At this location a line looping program in progress at that time provided an almost ideal combination of flow rate and pressures on the line to fully load the unit within the compression ratio available from the single impeller booster. The flow rate was to be high for several months. Since metering for the main line flow was installed, operation of the station block gate and discharge gate would permit any lower flow to be established for testing. Higher than line capacity flow rates could be established by recycling a portion of the gas through the block gate from the discharge back to the suction. Too high a raise in suction temperature was not desirable, so only a limited increase in the test flow rate above the line capacity was attempted.

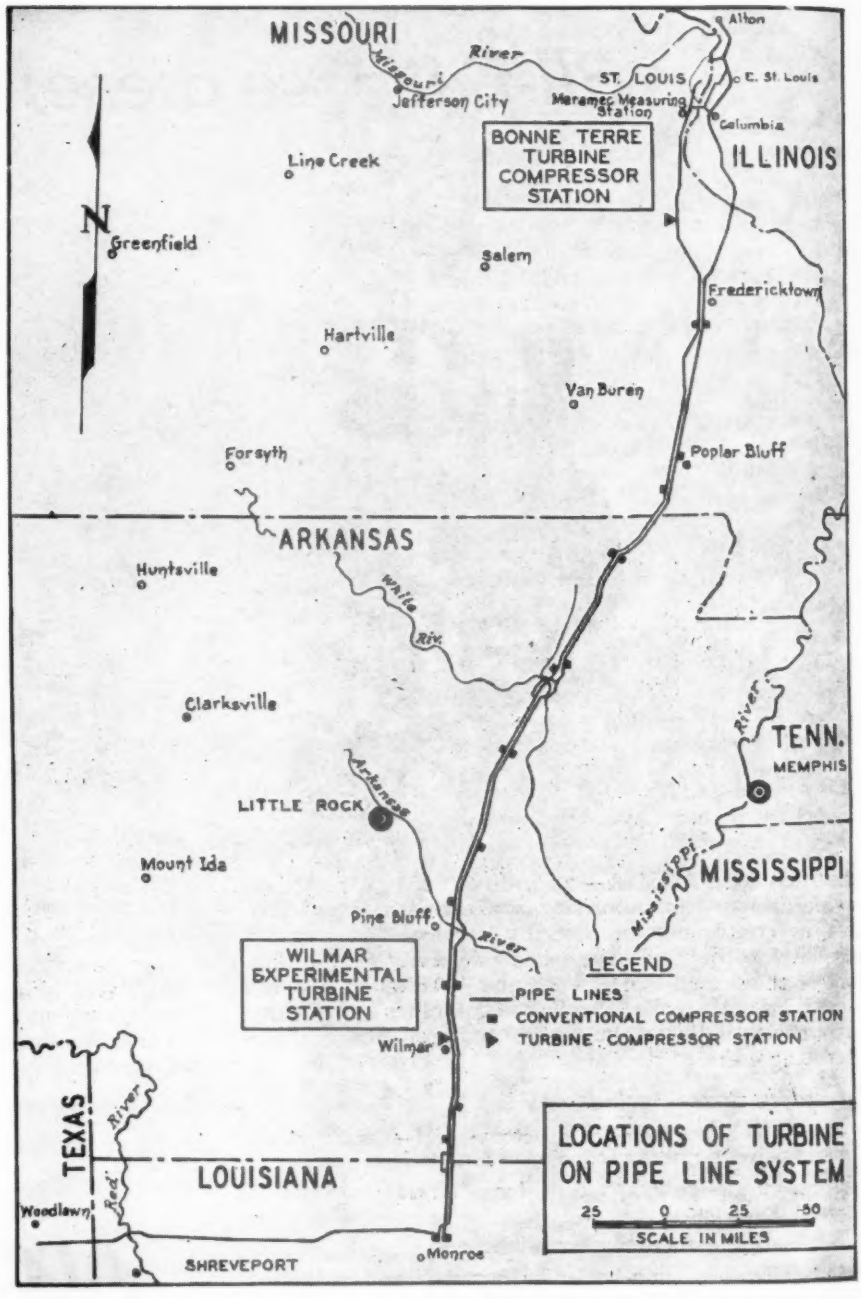
Later in the looping program when the second line was built past the station, sustained runs were made at the lower flows which resulted in the line on which the unit was in service.

Station Location Changed

In the fall of 1950 it was determined to move the turbine station to the market end of the No. 1 Main Line. This end of the line operates at a discharge pressure of 425 psi. The location at Bonne Terre, Missouri, is valuable to increase the peak hourly flows and delivery pressures into Meramec Measuring Station adjacent to St. Louis for assistance in handling winter peaks caused by heating requirements, and to divert gas in the summer from the No. 2 main line. The increase in delivery pressure on the No. 2 line was utilized to deliver gas in the summer of 1951 without a field compressor to an experimental underground storage facility being tested.

Improvements Made

A number of improvements in design of the compressing station were incorpo-



MAP SHOWS locations of pipe lines, conventional compressor stations and turbine compressor stations of the Mississippi River Fuel Corporation's system.

†Presented at Southern Gas Association meeting, New Orleans, Louisiana, 1953.

*Chief Engineer, Mississippi River Fuel Corporation, St. Louis, Missouri.

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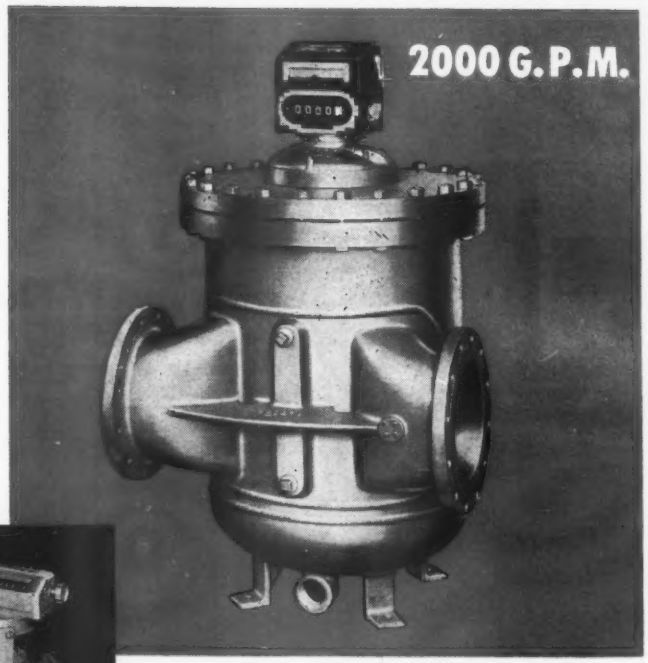
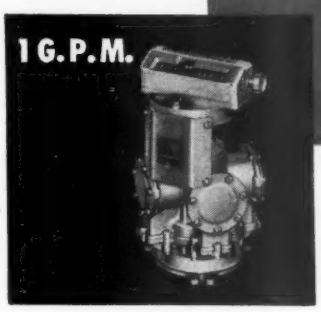
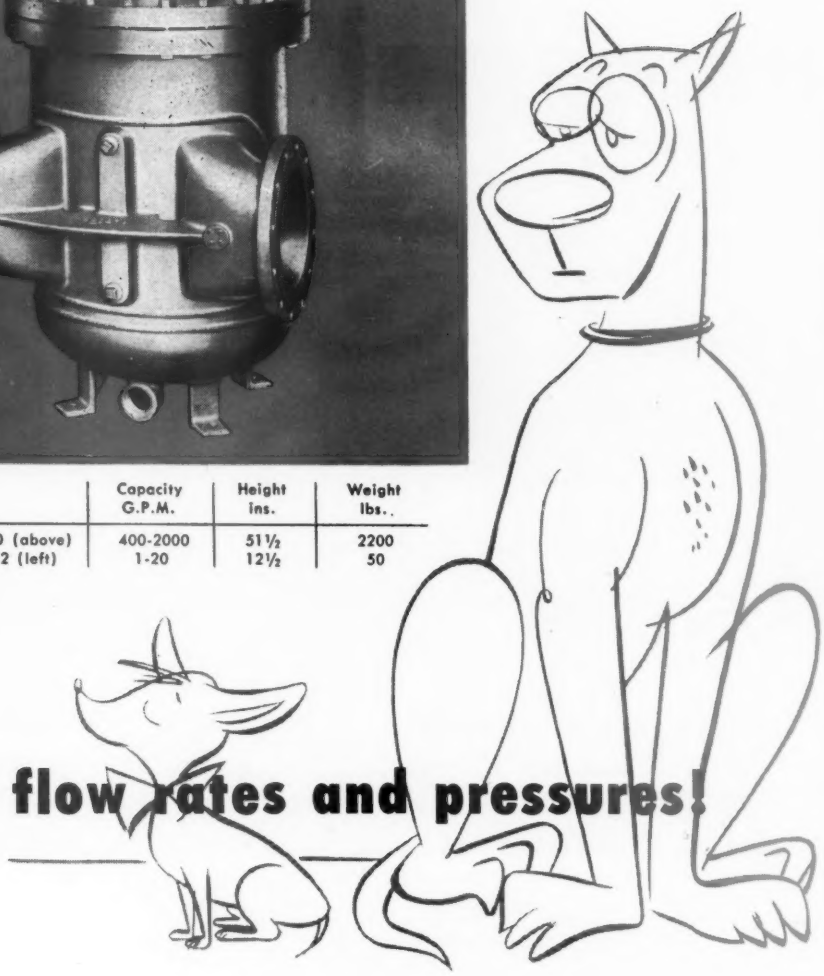




	Capacity G.P.M.	Height ins.	Weight lbs.
B-200 (above)	400-2000	51½	2200
APM-2 (left)	1-20	12½	50



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Yes, A. O. SMITH offers you the widest range—flow rates from 1 G.P.M.; pressures to 2000 P.S.I. Types and sizes for every step of petroleum measurement from well to consumer. All are known for *sustained* accuracy, long life, dependability, lowest maintenance cost, ease of installation and service. Most complete line of *functional* accessories, too. See nearest representative or write A. O. Smith Corporation, Meter Division, 5715 SMITHway St., Los Angeles 22, California.

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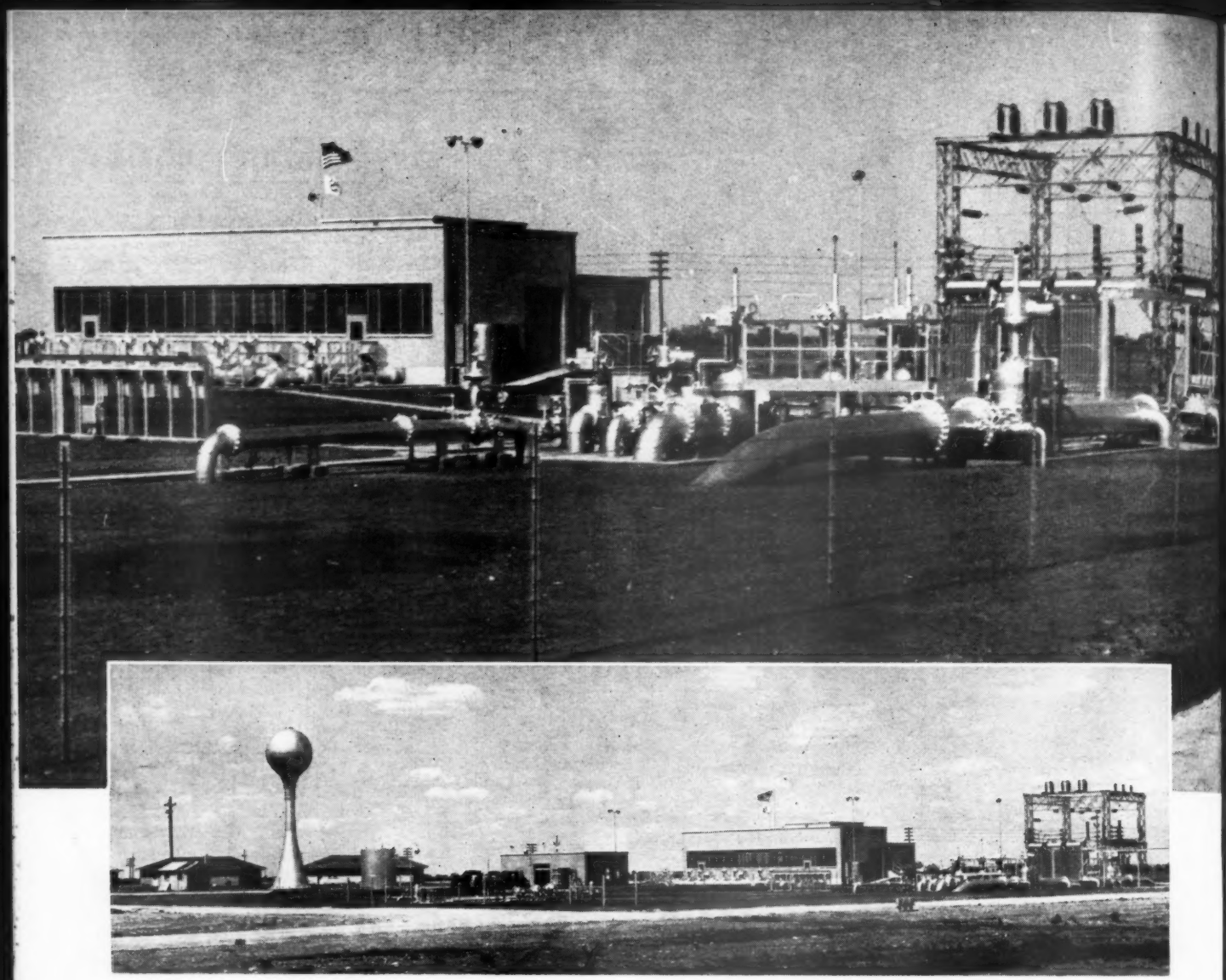

ONE OF THREE

- Pump Stations and Tank Farm Systems on the Rancho Pipe Line System built by Station Construction Company.

In this era of specialization, Station Construction Company brings pipe line owners the services of a completely integrated and skilled organization for the construction of pump stations, gas compressor stations, tank farm systems and terminals.

STATION CONSTRUCTION COMPANY

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rated in the permanent station. Gas piping, oil piping, electric wiring, and other facilities were revised and simplified. It was unnecessary to meter the main gas since the station is only a short distance from Meramec measuring station where the output of main line No. 1 is metered. Larger piping was installed between the main line and compressor to reduce the pressure drop through the station. Unfortunately, the station was urgently needed for the winter load. Lack of time to secure new equipment and modify the turbine necessitated utilization of equipment and facilities from the experimental station which precluded incorporation of some desirable features in the permanent station. Regular compressor station operators in charge of the station foreman were assigned to tours of duty here.

By January 19, 1951, the facilities to operate the turbine on oil were completed. Because of the great expense of the oil fuel it was used only when essential to deliver gas in peak hours and on days of high demand. New combustors of improved design to burn fuel gas were installed March 9, 1951, and on May 1, 1951, the turbine station was placed in regular pipe line operation to serve as the dispatching required.

1951 Operating Experiences

A summation of "Operation of Bonne Terre Station During 1951," Table 1, has been prepared. The hours of operation with oil fuel to serve the load on peak days and during peak hours to move the line pack are shown at the top of the table. It is interesting to note that a freak cold front struck the station February 1 and when the turbine was started up that morning it was 22 F below zero. There was a short delay starting while the No. 2 fuel oil was heated to get it moving. (The design criterion in this area is 0 F).

The operation with gas fuel during the summer to divert gas to line No. 1 from line No. 2 (which operates at a discharge pressure of 700 lb) for the benefit of experimental storage project, and the operation during the fall and winter to improve flow and pressure conditions for delivery of line pack and serve hourly and daily peak loads is also shown in Table 1.

Table 2, "Station Department Summary of Average Operating Conditions, Bonne Terre Station for Year 1951," offers additional data.

In general, the only operating difficulty of any consequence was a shut down from June 26 to July 10 to tighten the rotor blading in the slots of the solid type rotor then in use. It was determined to install a disc type rotor as soon as the design and testing should have been completed. The summer operation proved that added turbine lube oil cooling would be required. Additional insulation was provided on the compressor to eliminate icing trouble with the seal oil return pressure reduction valve. No discontinuity of service was occasioned by the cooling or icing problems.

1952 Operating Experiences

Experiences in 1952 are tabulated in "Operation of Bonne Terre Station During 1952 With Gas Fuel," Table 3. Installation of a field compressor station in the experimental storage field to test deeper formations eliminated the requirement that the turbine station be operated during the summer. It was still required in the fall and winter.

On January 27, a new manifold and dual fuel (oil and gas) nozzles were installed in the combustors. Change in fuel while operating from gas to oil and the return to gas was successful.

On February 22, blade failure occurred and the rotor and stator blading was destroyed. This rotor had been in serv-

TABLE 1. Operation of Bonne Terre station during 1951.

	Hr Min	Remarks
With Oil Fuel		
January	69:10	Operated 1/19, 20, 24, 25, 26, 29*, 30*, 31* only
February	28:10	Operated 2/1*, 2*, 7, 8, 14 only
March	3:50	Operated 3/9 only (Improved gas combustors installed)
With Gas Fuel		
April	6:10	Operated 4/1 only
May	110:40	Began intermittent operation 5/7
June	151:40	Discontinued operation 6/27
July	236:22	Began intermittent operation 7/10
August	389:05	
September	172:00	Operation intermittent 9/4 to 19, inclusive
October	162:25	Began intermittent operation 10/8
November	644:00	Began continuous operation 11/11
December	716:45	
	2589:07	

* Note:—

Date	Mean temperature St. Louis area F
1/29	3
1/30	4
1/31	8
2/1	1
2/2	11

TABLE 2. Station department summary of average operating conditions Bonne Terre station for year 1951.

Fuel Oil Operation

Hours operated on fuel oil — 118.
Oil Average Heating Value — 140,000 Btu/gal, 0.857 specific gravity.
Unit consumed approximately 200 gal/hour when delivering 1470 bhp
Calculated Thermal Efficiency — 13.3 per cent, .136 gal oil/bhp hour.
Lube oil consumption approximately 1 gal/24 hours.
RPM varied between 8000 and 8450.
Average combustor temperature — 1225 F (Winter).

Natural Gas Operation

Hours operated on gas — 2581.
Gas average heating value — 1045 btu/cu ft, .60 specific gravity.
Unit consumed 23.4 mcf/hr when delivering 1540 bhp.
Calculated thermal efficiency — 16.0 per cent, 15.19 cu ft gas/bhp hour.
Lube oil consumption approximately 1 gal/24 hours.
RPM relatively constant at 8000.
Average combustor temperature — 1080 — 1100 F (Winter)
Average combustor temperature — 1150 — 1200F (Summer)

TABLE 3. Operation of Bonne Terre station during 1952 with gas fuel.

	Hr Min	Remarks
January	551:55	Continuous operation to 1/15, then intermittent
February	316:35	Rotor failure occurred after 3228 hours operation—2918 hours "on the Line". 2/23
March	85:20	Repairs completed on rotor 3/23
April	279:25	Intermittent operation
May	214:35	
June	10:40	6/2 Turbine not required until August 20th
July	None	
August	105:20	Began intermittent operation 8/20
September	632:27	Began continuous operation 9/15
October	714:12	
November	633:55	Off Line 11/14, 15 and 16 to install new disc type rotor. 2237 hours on replaced rotor.
December	743:45	1071 hours on new rotor at year end
	4288:09	

CLEANING, COATING, WRAPPING & RECONDITIONING

★

HOT DOPE

Straight from the Kettle on PIPE PROTECTION

★

By Boyd Mayes

• Met up with an old pipeliner friend and customer the other day I hadn't personally seen for some time. Got to talking about the changing times —lines, little and big, people in general, and business ups and downs.

Asked him by way of information, if he had a reason for "buying my wares" so often over the years— 'stead of somebody else's. He says: "Too many people in business selling *expendable goods*—darn few selling *dependable*—". He went on to say he bought the latter every time he could 'cause he'd sorta got used to QUALITY.

Sounded good to us, and we thanked him for keeping us on his "buying list."

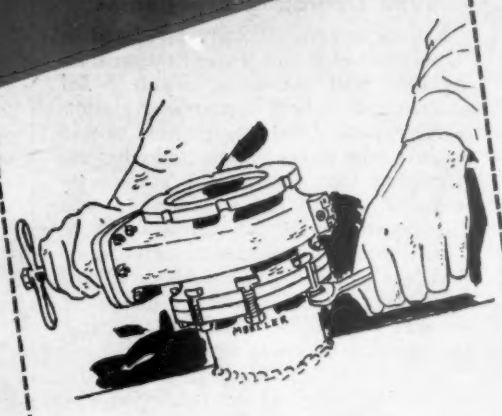
We are sorta proud of our over a quarter of a century of service to just about everybody in the pipe line business . . . and we keep right on believing that doing our *special job* well is assurance we'll see customers again and again. "Cleaning, Coating, Wrapping and Reconditioning Pipe" is still our business.

MAYES BROS.

1150 McCarty HOUSTON, TEXAS ORchard 7566

STEP 1. WELD NIPPLE TO LINE

COMPLETION PLUG SHOULD REMAIN IN FITTING - **HAND-TIGHT** - DURING WELDING OPERATION. REMOVE PLUG AND BOLT TEST CAP IN PLACE. TEST WITH AIR AND SOAPSUDS.



STEP 2. BOLT GATE VALVE TO NIPPLE

USE ONLY THE SPECIAL MUELLER GATE VALVE WHICH SHOULD BE INSTALLED WITH SEAT RING ON TOP SO LINE PRESSURE WILL AID IN KEEPING GATE CLOSED.

STEP 3. DRILL HOLE INTO LINE

CUT IS MADE WITH A MUELLER C-1, POWER-OPERATED, OR C-C, HAND OPERATED DRILLING MACHINE. CLOSE GATE VALVE, REMOVE DRILLING MACHINE AND ATTACH LINE TO GATE VALVE. **NOTE:** BE SURE NIPPLE AND PIPE ARE COOL BEFORE STARTING CUT TO AVOID DRAWING HARDNESS FROM CUTTER.

SAVE VALVES WHEN ABANDONING TEMPORARY LINES

H-17495

Mueller Save-A-Valve Drilling Nipples may be used to make a connection under pressure to any tank or pipe line, without loss of fluid. In addition, they make it possible to remove and re-use expensive valves when abandoning the connection and even to re-use the connection at some future time.

This is done by using an inside thread which permits the insertion and removal of a threaded plug under pressure, effecting a tight shut-off before the valve is removed. A completion cap, which is attached to the nipple in place of the gate valve, provides a double seal and eliminates possible leaks.

Typical uses for Save-A-Valve Drilling Nipples are for gathering-line connections in the gas and oil fields, for purging and by-passing connections used with Mueller Line Stopping Equipment or other similar temporary installation.

H-17495 Save-A-Valve Drilling Nipples are made of heavy seamless steel tubing. The inlet end is machine chamfered for welding and the outlet end has a special series 15 steel flange made to be used with the Mueller H-17235 Stopping Machine and Valve. These H-17495 nipples are made in the 4" nominal size only. Other Save-A-Valve Drilling Nipples are available in nominal sizes from 1" through 3".

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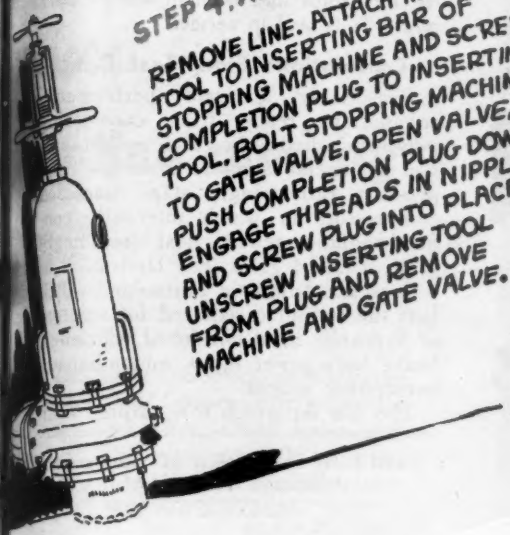
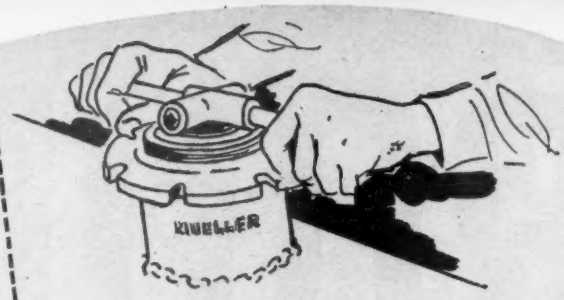


STEP 4. ABANDON CONNECTION

REMOVE LINE. ATTACH INSERTING TOOL TO INSERTING BAR OF STOPPING MACHINE AND SCREW COMPLETION PLUG TO INSERTING TOOL. BOLT STOPPING MACHINE TO GATE VALVE, OPEN VALVE, PUSH COMPLETION PLUG DOWN, ENGAGE THREADS IN NIPPLE AND SCREW PLUG INTO PLACE. UNSCREW INSERTING TOOL FROM PLUG AND REMOVE MACHINE AND GATE VALVE.



STEP 5. TIGHTEN PLUG

A SPECIAL WRENCH IS PROVIDED TO TIGHTEN COMPLETION PLUG. A PIPE OR ROD IS PLACED THROUGH THE WRENCH TO PROVIDE LEVERAGE.

STEP 7. FUTURE USE OF CONNECTION

REMOVE COMPLETION CAP AND LOOSEN PLUG. ATTACH EXTRACTING TOOL TO COMPLETION PLUG. THEN BOLT GATE VALVE AND STOPPING MACHINE IN PLACE. ADVANCE INSERTING BAR UNTIL IT CONTACTS EXTRACTING TOOL AND TURN COUNTER-CLOCKWISE UNTIL PLUG IS SCREWED OUT OF NIPPLE. RAISE INSERTING BAR, CLOSE VALVE AND REMOVE STOPPING MACHINE. LINE MAY NOW BE ATTACHED TO GATE VALVE. (STEP 3)

STEP 6. COMPLETE ABANDONMENT

WHEN PLUG HAS BEEN TIGHTENED, PLACE GASKET IN RECESS IN FLANGE OF NIPPLE AND BOLT COMPLETION CAP SOLIDLY TO FLANGE. ABANDONMENT IS NOW COMPLETE AND VALVE HAS BEEN SAVED FOR RE-USE.

MUELLER NO-BLO Method

This is another of a series of gas distribution problems and their step-by-step solution by Frank Miller, Gas Service Engineer of Mueller Co.

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PROOF

HERE'S HOW TAPECOAT® HAS STOOD THE TEST OF TIME TO SOLVE CORROSION PROBLEMS

PROOF (Underground) — Inspection of TAPECOATED joints after 10 years of underground service showed no sign of corrosion when the TAPECOAT was removed.

PROOF (Alternate wetting and drying) — Expense and trouble in protecting lines subject to wet and dry conditions at cooling towers have been eliminated since 1944 by coating with TAPECOAT.

PROOF (Underwater)—During the re-laying of an underwater pipe line in the Gulf area, examination showed that TAPECOAT had protected the pipe against salt water corrosion and barnacles.

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Actual experiences like these show what TAPECOAT coal tar protection can do for you.

Use TAPECOAT to combat corrosion above or below ground on gathering lines, transmission lines, meter stations, compressor stations, distribution lines, pipe joints, bolt-type couplings, fittings, large bends, large diameter pipe, insulated lines, tanks, and other surfaces subject to corrosion.

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The TAPECOAT Company

Originators of Coal Tar Tape Protection

1533 Lyons Street, Evanston, Illinois

ice for 3228 hours. For the first time in history, we are told, a reblading job on this type of unit was done in the field. One month later, by March 23, repairs were completed. The repaired rotor was used until November 14 and 15 when a shutdown was made to install the new disc type rotor which had been received from the factory. By the end of 1952 the new rotor had been in service 1071 hours. It is still in service.

Calculations From Test Data

Reasonably accurate performance calculations result from considering polytropic, hydraulic, and temperature rise efficiencies identical in the low compression ratio single stage uncooled compressors in which internally confined radiation renders heat losses negligible. Table 4 gives the "Derivation of Values for Adiabatic Formulae" which lists the formulae required for solution of hydraulic head developed, efficiency, brake horsepower input, and adiabatic horsepower output.

The gas on which this turbine com-

TABLE 4. Derivation of values for Adiabatic formulae.*

1. $K = \frac{C_p}{C_v} = 1.296$

   Then

2. $\frac{K-1}{K} = \frac{1.296-1}{1.296} = .2285$

3. From $T_2 = T_1\left(\frac{P_2}{P_1}\right)^{\frac{K-1}{KE}}$

   Where T_1, T_2, P_1 and P_2 are absolute values

   E = adiabatic efficiency

4. From $T_2 = T_1\left(\frac{P_2}{P_1}\right)^{\frac{.2285}{E}}$

5. And $H_a = 144\ P_1V_1\frac{K}{K-1}\left[\left(\frac{P_2}{P_1}\right)^{\frac{K-1}{K}} - 1\right]$

   Where H_a is the hydraulic head in ft lb/lb

6. And $H_a = 144\ P_1V_1\beta$

   Where β is the mean effective pressure ratio.

7. And $H_a = RT_2\beta$

   Where R is the gas constant divided by mol wt.

8. And $H_a = 89.0\beta T_2$

   Where $\frac{1545}{17.34} = 89.0$

9. And $H_a = \frac{\text{Head in lb/sq inch}}{\text{conversion factor}}$ (Fig. #2)

   Where mol wt is $.6 \times 28.9 = 17.34$

10. $144\ P_1V_1 = 1545\ zNT_1$

    Where $N = \frac{1}{17.34} = \frac{1}{\text{mol wt}}$

11. $V_1 = \frac{89.0\ zT_1}{144\ P_1}$

    Where V_1 = Volume of 1 lb of gas in cubic feet at P_1 and T_1

12. Head in lb/sq inch $= \frac{H_a}{144V_1}$

13. Head in lb/sq inch = $H_a \times$ conversion factor (Fig. #2)

14. B.H.P. $= \frac{\text{Wt flow \#/Min} \times H_a}{33{,}000 \times E}$

15. B.H.P. $= (\#/\text{Min} \times V_1) \times \frac{144}{33{,}000} \times \frac{P_1\beta}{E}$

*Basic formulae from paper presented before the December, 1946, meeting of the California Natural Gas Association revised and presented before the October 11, 1947, meeting of the Oklahoma Section, American Society of Chemical Engineers, by T. R. Foster, manager, turbine machinery sales, Clark Bros. Company, Inc., Olean, New York.

How SUNRAY OIL boosts pipe line capacity 25%

Three years ago production skyrocketed at the Sunray Oil Corporation refineries in Duncan and Allen, Okla. Expansion throughout the system overloaded the 6-inch pipe line between the two cities. Bigger pipe was not available.

Sunray engineers hit on a cost-cutting solution—installed three electrically powered booster stations between regular pumping stations. They know that electric motors cost less to install . . . require little maintenance . . . are easily adapted to remote control circuits.

Then engineers selected an RCA 960-mc Microwave radio-relay system to effect complete remote control of the *"boosters"* from regular pumping stations. Microwave stations spaced miles apart proved cheaper to install and maintain than direct wire. And Microwave systems are virtually weatherproof.

When the Sunray microwave-operated *"boosters"* were put in operation on January 31, 1952, *the pipe line's capacity immediately increased 25 per cent!*

RCA Microwave "beams" highly directional radio signals from station to station by "dish" antennas. Since 1946 RCA has installed many fully reliable Microwave systems, some over 1,000 miles long. *All have proved themselves in performance*—for utilities, government agencies, telegraph companies, turnpikes, as well as pipe lines.

In addition to remote control and supervisory functions, RCA Microwave provides as many voice and teletype channels as you need—and does it with a minimum of frequency space. It employs readily available tubes and familiar circuits which are easy to service. It interconnects with your telephone lines and switchboards.

If you desire, RCA supervises survey, construction and installation—offers a complete single-source, single-responsibility service. And only RCA can provide the nationwide service facilities of the RCA Service Company.

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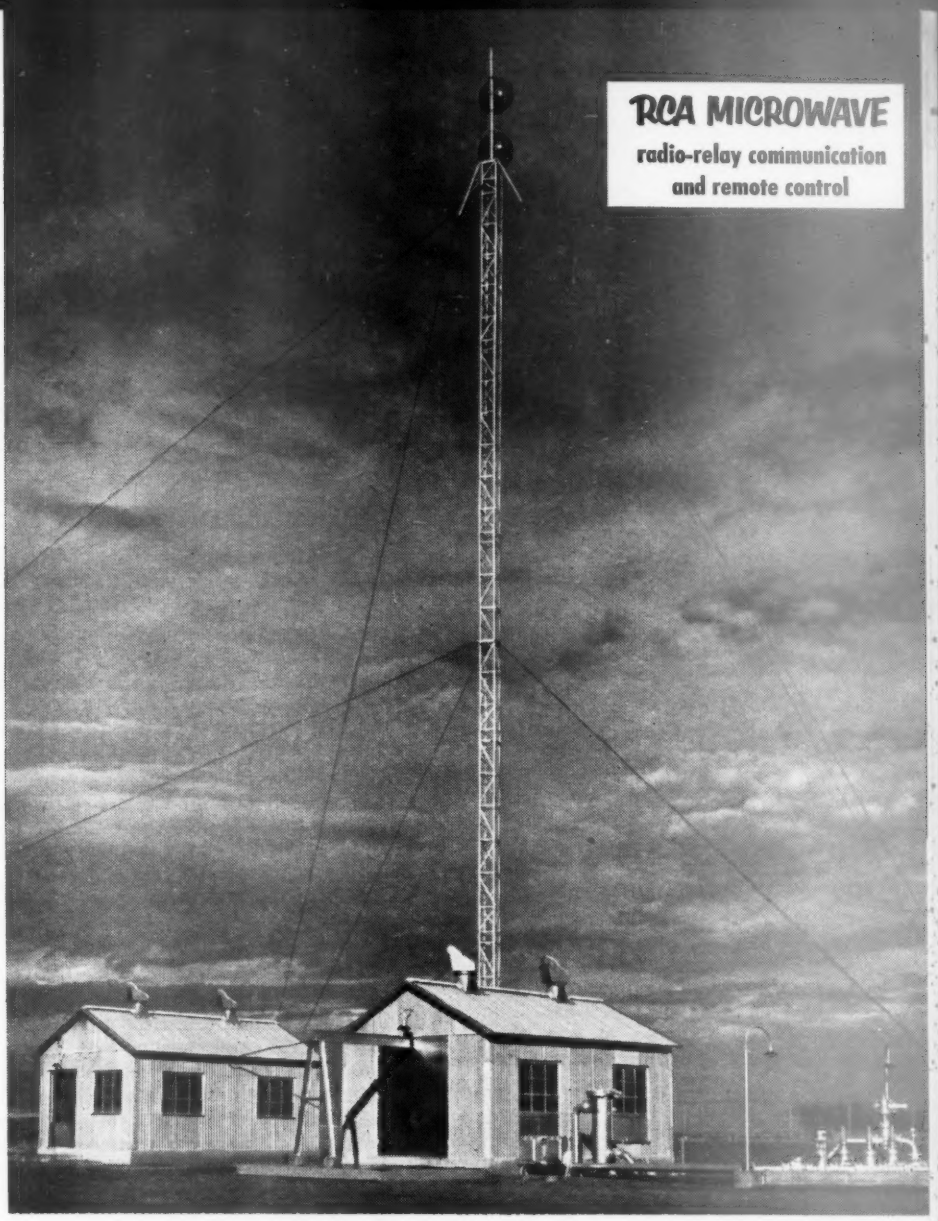
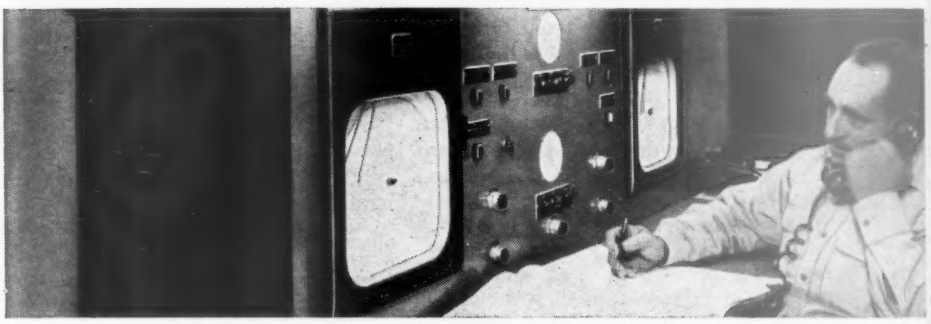


Unattended booster station at Pernell, Okla. Radio-beam signals via RCA Microwave operate the booster by full remote control. Maintenance man inspects each station once every 24 hours.



Telemeter charts give continuous record of power and pressures at boosters. Operator remote-controls valves and pumps of booster stations. Signal lights indicate equipment failure and emergency generator operation. 2-way voice channel contacts maintenance personnel.

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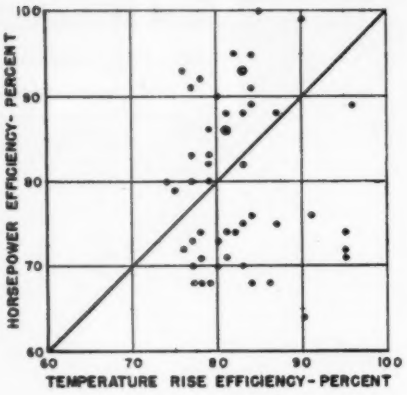

FIG. 1.

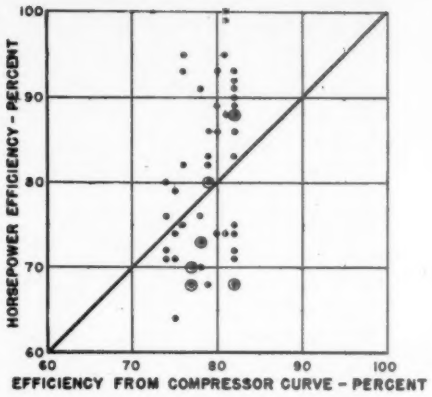

FIG. 2.

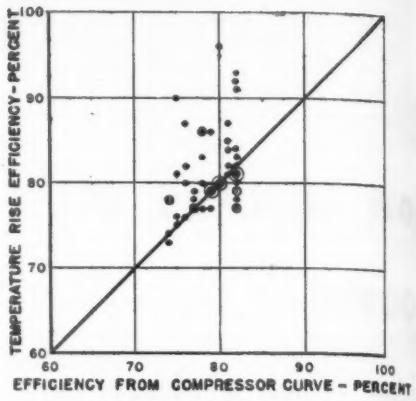

FIG. 3.

Correlations of efficiency calculated from Wilmar station data. Fig. 1 is HP efficiency against temperature rise efficiency. Fig 2 is HP efficiency against compressor curve efficiency. Fig. 3 is temperature rise efficiency against compressor curve efficiency.

pressor unit was tested has the following characteristics:

Ratio of specific heats $\frac{C_p}{C_v} = 1.296$

Specific gravity .60 Molecular weight 17.34

Pressure base of flow data 14.9 psia

For your convenience an actual set of data has been computed as an example and the procedure shown on Table 5.

From this typical calculation, it is evident that reasonably accurate results can be obtained from rather simple field data concerning the performance of a gas turbine and compressor unit. Considerable care must be exercised to properly locate and to use accurate thermometers since the temperature difference is small. Pressures should be taken at proper locations and very accurately, preferably with deadweight gauges. The flow through the unit and the fuel consumption should be carefully measured.

Figs. 4, 5, and 6 graphically compare the calculated compressor efficiency by the horsepower graphs provided with the turbine compressor unit, by the temperature rise efficiency calculations from actual temperatures obtained in operation, and from the factory calibration curve of the gas compressor.

It was explained to us by the research departments that the temperature rise efficiency method depends on a small difference in temperature which is difficult to measure accurately. A 1 F error in reading makes about a four per cent error in the result. But, even with this fault, it is more consistent than the calculation of the turbine power output simply because there are fewer variables involved.

Determination of the turbine power output is a function of air temperature and humidity, blade fouling in the air compressor and many other factors quite difficult to evaluate in the field.

All of our tests and calculation verify the above observation by the manufacturers. It is much simpler and consistently more accurate to determine compressor shaft horsepower required rather than to try to obtain the shaft horsepower as delivered by the turbine. In fact, it is about the only method which can be easily applied in the field to obtain performance figures which are reasonably correct.

Operating Conclusions

The following conclusions represent the considered opinions reached through operating and studying the simple unit which is a part of Mississippi's pipe line system. The six or eight months since they were set down has brought forth no significant changes as a result of the further experience.

Unit Description. The 1850 hp internal combustion gas turbine coupled to a centrifugal compressor is a practical unit for compression of gas on pipe lines. It is capable of sustained operation and has developed 2000 bhp under test loading. Certain features of the gas turbine unit make it attractive for the solution of specific problems encountered in gas transmission. A station using turbines has a low installation cost per horsepower, necessitates a small physical area per unit minimizing the expense of buildings, and requires very little concrete in foundations. No station auxiliaries need be provided except an office, sanitary and drinking water, a minimum of electric power, fuel oil storage facilities if required, and a small storeroom for stores and supplies.

Training Personnel. Regular station personnel is capable of learning quickly to operate and maintain a turbine compressor unit. Our experiences indicate that if only a few changes were made in auxiliary equipment the station could be operated with only one person per tour. The turbine is well suited to application of automatic protective and operating devices which may make future designs of such a unit able to function unattended.

Flexible Unit. No instability or flutter in gas compressor operation was found from 110,000,000 cu ft per day rate of flow to 233,000,000 cu ft per day (corrected to 8750 rpm and 400 psia discharge pressure). The compressor design point was 190,000,000 cu ft per day under these conditions. Stable flow rates from 77,000,000 to 191,000,000 cu ft per day (actual measured—uncorrected for

TABLE 5. Example of calculation of data.

Data: Date, September 8, 1949, time, 6:00 p.m., 1000 Btu @ 60 F, 14.9 psia, fuel 740 mcf/day turbine speed 8750 rpm.

Turbine air inlet 83 F, combustor temperature 1266 F

Gas volume 183.2 mmcf/d at 14.9 psia

Gas inlet temperature 76 F = 536 K. Outlet 100 F = 560 K.

Gas inlet pressure 298.0 psia, outlet 340.4 psia (I. R. Co. research department calculated E = .77)

Computation: Equations from Table 4.

1. From Equation 4 $T_2 = T_1\left(\frac{P_2}{P_1}\right)^{\frac{.2285}{E^*}}$

$$560 = 536\left(\frac{340.4}{293.0}\right)^{\frac{.2285}{E^*}}$$

2. $$\frac{560}{536} = (1.161)^{\frac{.2285}{E^*}} = 1.046$$

3. $E^* = \frac{.2285}{.3015} = .76$

4. From Equation 8 $H_a = 89.0\beta T_2 = 89.0\beta$ (560)

5. From Fig. 1 $\beta = .151$
$H_a = 89.0(.151)(560)$

6. $H_a = 7526$ (calculated)

7. From Equation 13 $H_a = \frac{P_2 - P_1}{\text{Conversion factor}}$
$= \frac{340.4 - 293.0}{.0063} = 7510$ (actual)

8. From Fig. 2 conversion factor = .0063

9. From Fig. 3 183.2 mmcf/d = 5900#/min of gas

From Equation 14 and (3) (6) and (9) above:

10. BHP = $\frac{\#/\text{min} \times H_a}{33{,}000 \times E} = \frac{5900 \times 7526}{33{,}000 \times .76} = 1766$

From Equation 14 and (7) (9) and I. R. Co. calculated efficiency

11. BHP = $\frac{5900 \times 7510}{33{,}000 \times .77} = 1743$

12. Agreement of (10 and (11)
$\frac{(1766 - 1743)100}{1743} = 1.3\%$

**Efficiency = $\frac{\text{Btu output}}{\text{Btu input}}$

**Efficiency = $\frac{\text{BHP} \times 24 \times 2545 \times 100}{\text{Gas cf/d} \times \text{Btu/cu ft}}$

13. **Efficiency = $\frac{1743 \times 24 \times 2545 \times 100}{740{,}000 \times 1000}$

14. **Efficiency = 14.4%
Adiabatic hp output of the compressor is the bhp × efficiency*

15. From (11) Adiabatic hp = 1743 × .77 = 1340

*Hydraulic efficiency.
**Thermal efficiency.

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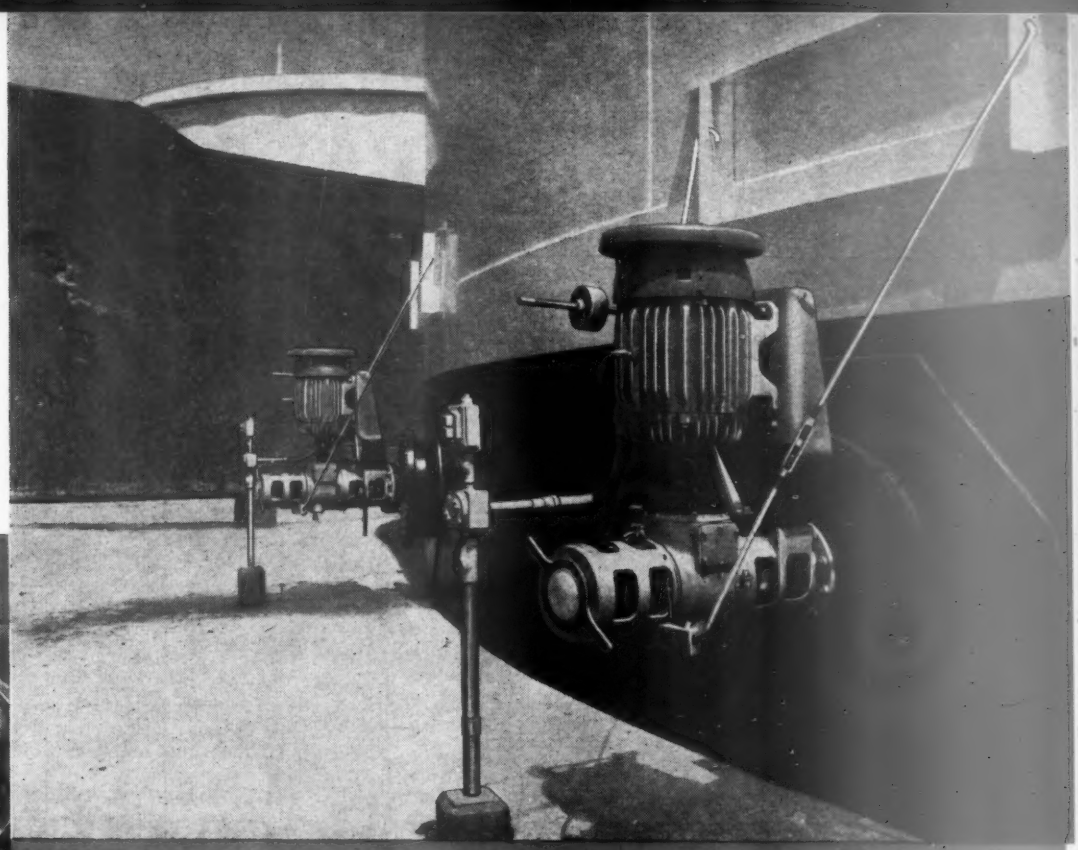

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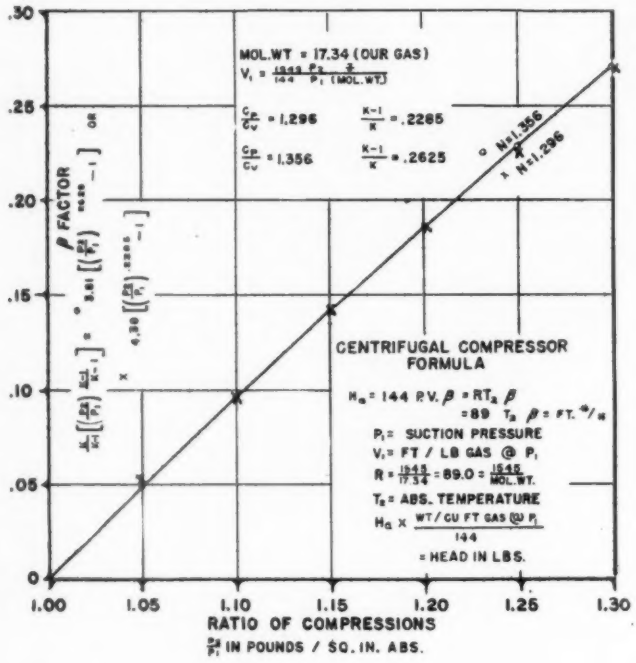


FIG. 4. Compression ratio plotted against factor. (See Table 2.)

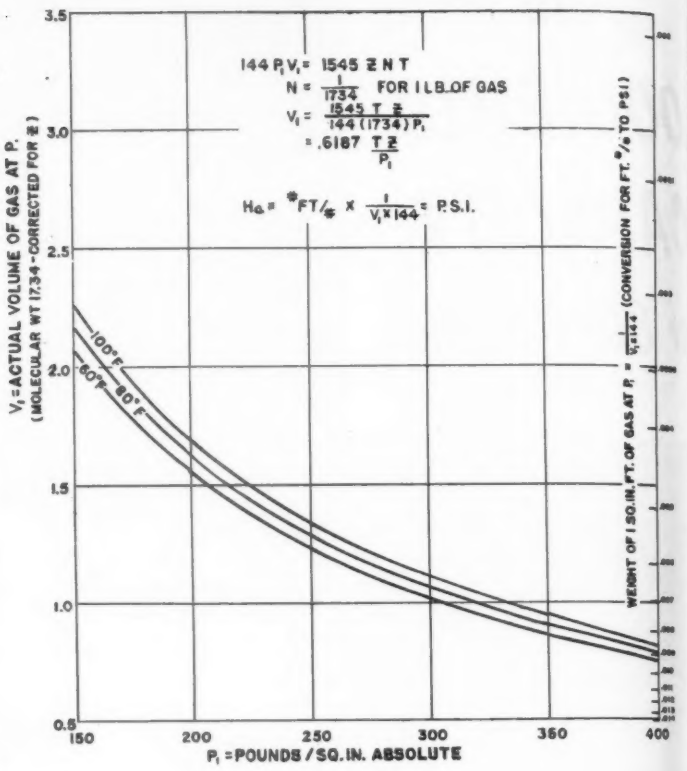


FIG. 5. Graph for calculating adiabatic head and centrifugal-compressor volume.

speed or discharge pressure) were handled by the compressor at pressure ratios from 1.225 (at 179,000,000 cu ft per day corrected and 8750 rpm) to 1.164 (216,000,000 cu ft per day corrected and 8750 rpm). At low speed and high load the compressor developed a pressure ratio as low as 1.139 and at high speed and low load a ratio as high as 1.241. Suction pressures from 228 to 347 psia, which were established during the operating test, made only a slight change in the ratio of pressures developed for an equal flow rate. The unit was very flexible for handling changing loads at low ratios of pressures.

Direct Connection. The direct connection between the turbine and compressor did not permit independent variation of the compressor speed to use the full horsepower output of the turbine at capacities less than the design flow rates. The data show that the unit operated a considerable portion of the time at less than the 1850 rated hp even though it is capable of producing 2000 hp when proper loading conditions occur in the course of pipe line operation. Another result of this direct connection, and the resulting operation at lower than optimum design rating, is actual thermal efficiency lower than design efficiency. At these lower flow rates usually experienced in regular operation the thermal efficiency of the turbine varied between 13.5 and 15.5 per cent. At a 2000 hp loading the thermal efficiency of the turbine was 16.5 per cent. It is concluded that separation of the turbine into a turbine to power the air compressor on one shaft with the axial flow air compressor, and a turbine on the other shaft with the gas compressor would permit operation at higher thermal efficiencies and greater range of gas compressor loadings than the simple cycle single shaft unit.

No Regenerator Used. Utilization of the exhaust heat of 750 F to preheat the combustion air at 60 psig by heat exchange should improve the thermal efficiency of a simple cycle unit as used in the test. A regenerator was not used in this series of tests because it was not deemed economical for this size unit.

Complex Equipment. The turbine, being a converted railway unit, was equipped with too many devices, controls and supervisory meters, for a unit used for strictly pipe line service.

Electrical Starting. Electrical starting facilities should be replaced by some type of gas operated equipment to make the turbine dependent only on the pipe line gas for starting.

Oil Consumption. Use of lubrication and seal oil has steadied down to about one gallon per 24 hours for both the turbine and compressor combined. This represents a tremendous saving in oil consumption when compared to conventional engine and reciprocating compressor units.

Fuel Consumption. The unit used about 238 gallons per hour of fuel oil or 28,000 cu ft per hour of 1045 Btu natural gas at full horsepower output. The turbine thus uses about 16,000 Btu per hour per brake horsepower. The type of oil that was used was many times more expensive than gas for fuel. Use of Bunker "C," for which the turbine combustors were originally designed, would have been more economical than operating with fuel oil.

Water Not Needed. No water is required for operation of either the turbine or compressor, which makes the unit very adaptable for intermittent service in cold climates, or for use in locations where water supply is extremely limited.

Pressure Drop. The relatively low ratio of pressures developed by the gas compressor makes it imperative to good overall station efficiency to design the main gas piping for very low pressure drop.

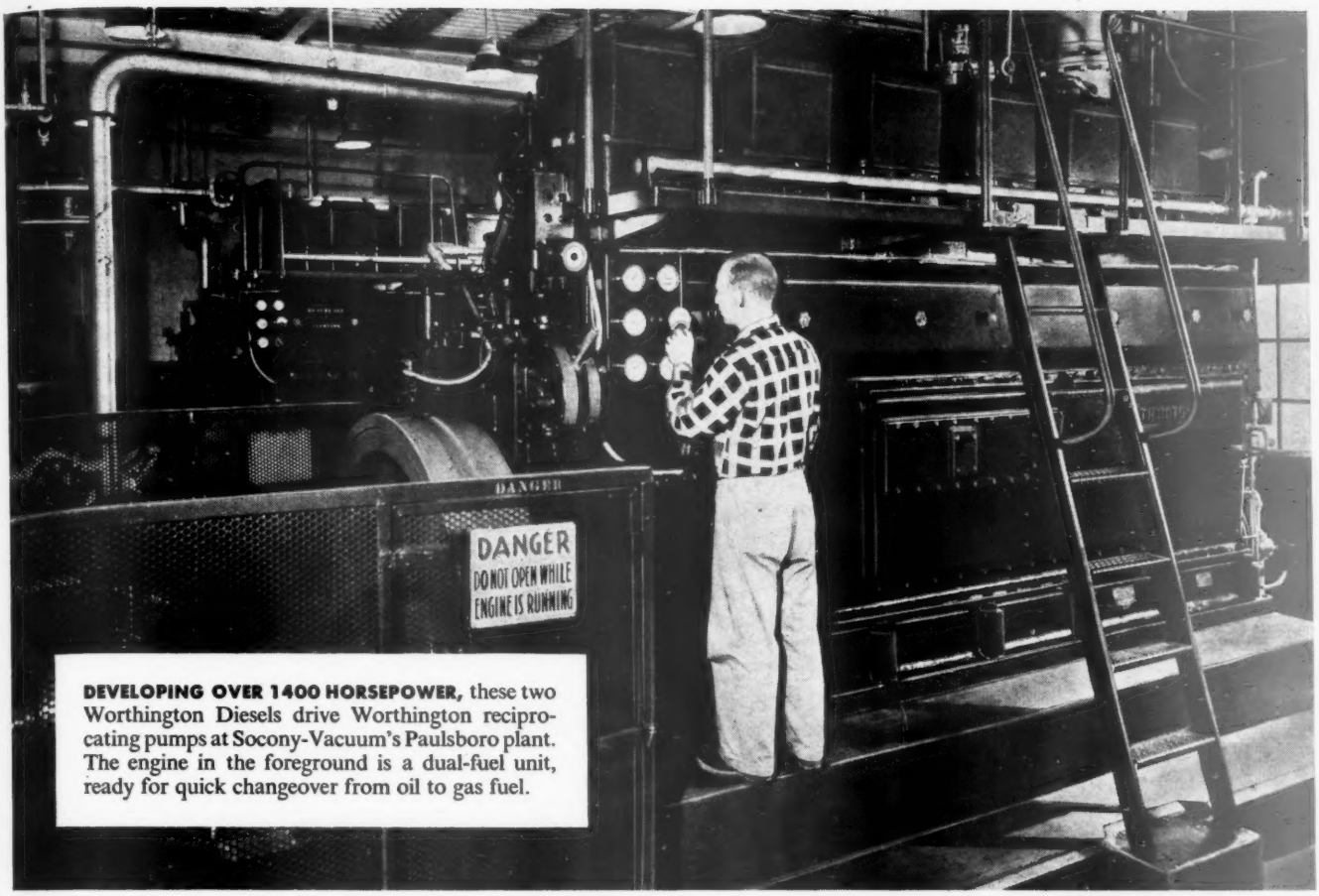
For field determination of the horsepower developed, the flow rate through the gas compressor is required. At Bonne Terre the station is close to Meramec measuring station, and the pressure drop occasioned by metering at the compressor station is avoided.

Thermal Efficiency. Improvement in thermal efficiency by the utilization of higher temperatures on future more advanced blading materials combined with the addition of heat recovery equipment should make this type of unit more desirable to the gas transmission industry.

Changes Recommended

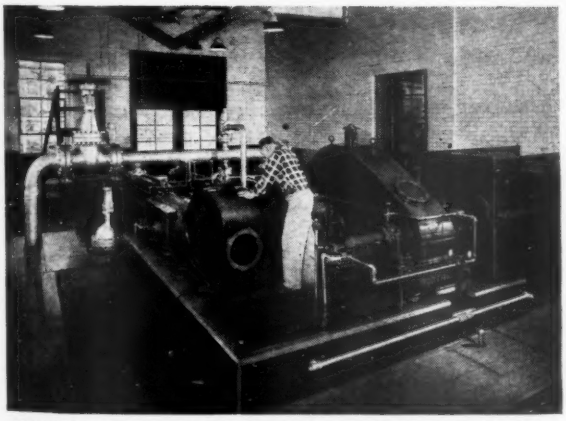
Tests have indicated that this converted locomotive turbine could be improved in stationary service by the following changes, many of which have been incorporated in later Westinghouse designs:

a. Placing the turbine end bearings outside the hot gas exhaust stack to



DEVELOPING OVER 1400 HORSEPOWER, these two Worthington Diesels drive Worthington reciprocating pumps at Socony-Vacuum's Paulsboro plant. The engine in the foreground is a dual-fuel unit, ready for quick changeover from oil to gas fuel.

Worthington Diesels power pumps along Socony-Vacuum line



DRIVING WORTHINGTON RECIPROCATING PUMPS like this one at the Paulsboro station is the job that Worthington engines along Socony's pipeline do with complete dependability. At the McCrea, Pa., booster station—midway along the line—continued pumping depends entirely on the driving power of a single Worthington Diesel, since no standby unit is used.

From their refinery at Paulsboro, New Jersey, through a booster station at McCrea, Pa., the Socony-Vacuum Oil Company pumps refined oil products across Pennsylvania to Pittsburgh.

Three Worthington Diesels—two at Paulsboro and one at McCrea—furnish all the power for driving the pumps on this 300-mile pipeline.

Socony-Vacuum's long, satisfactory experience with these dependable and efficient Worthington engines is duplicated by pipeline companies everywhere. Users know that when they buy Worthington dual-fuel Diesels they're getting the most for their dollar. The ability of the Worthington dual-fuel units to operate on crude oil from the line, Diesel oil, gas, or any combination of gas and oil, assures economical operation under all conditions.

Get all the facts on Worthington Diesels, dual-fuel or gas engines. Write to Worthington Corporation, Engine Division, Section E.3.4, Buffalo, N. Y. E.3.4

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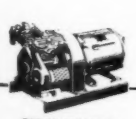
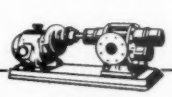
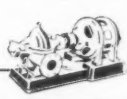
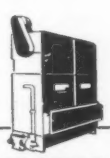

ENGINE STARTING COMPRESSORS


OIL TRANSFER PUMPS,


COOLING WATER CIRCULATING PUMPS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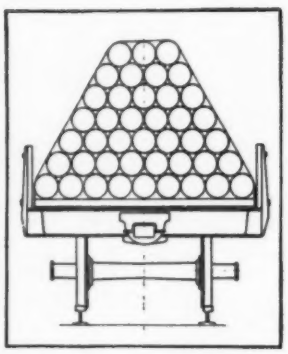

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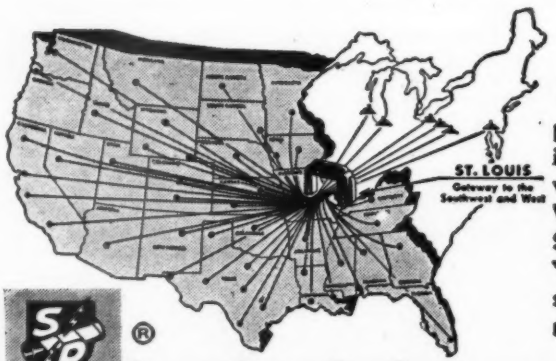

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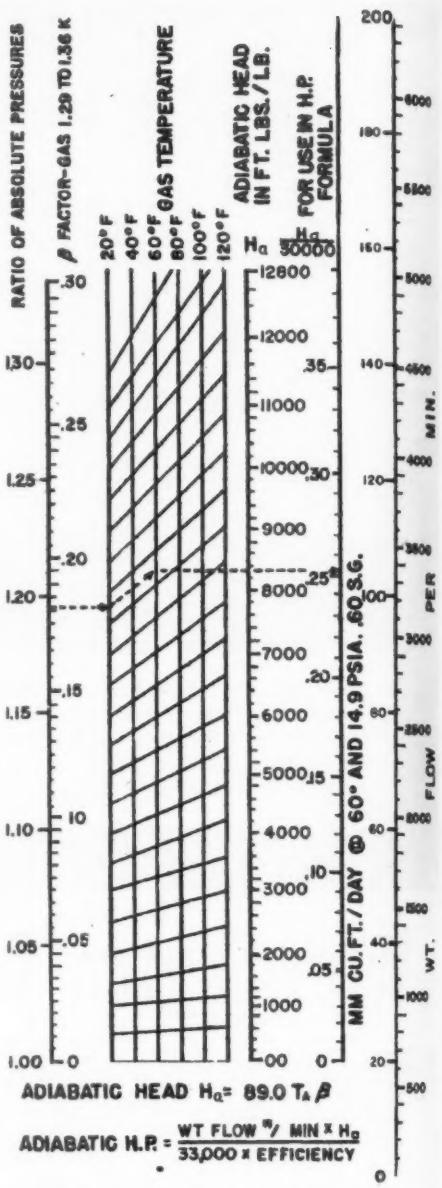

FIG. 6. Graph for calculation of horsepower and centrifugal-compressor head.

reduce heat transfer to the bearing and lubricating oil.

b. Supports for the turbine should be so designed that combustor heat will not cause distortion and effect the alignment of the turbine.

c. Research should be continued to further the design of the rotor.

d. The outlet stack for spent gases should be far enough from the air intake to prevent dirt and products of combustion vapors from entering the intake air stream to the air compressor.

e. During operation the turbine should furnish its own auxiliary power to prevent shut downs from power failures. A small gas engine generator or purchased power would be required for operation of emergency lighting and operation of the cooling down rotating motor.

f. Combination oil and gas combustors should be provided for operation in peak hour and peak day line packing service on the market end of the transmission line to save gas when it is vitally needed for customer service. * * *

PIPE LINE PROGRESS

Dope gang preparing a string of A. O. Smith 26-inch welded steel line pipe for lowering in on the West Texas Gulf Pipe Line.

Biggest Inch to carry 381,000 bbl. per day from Permian Basin area

The West Texas Gulf Pipe Line, completed last February, is the largest single carrier of crude oil in this country. It has 465 miles of 26-inch pipe which extends from Colorado City in west Texas to Lucas, just outside Beaumont.

Present capacity of 301,000 barrels per day is being increased to 381,000 by the addition of intermediate pumping stations. Ultimately, capacity can be increased further to an estimated 440,000 barrels per day.

Crude oil from the Permian Basin area, containing more than 20% of the nation's oil reserves, is delivered to the Beaumont area and, through a 20-inch branch of 112 miles, to Longview, Texas, where it connects with other pipe lines serving Great Lakes and Ohio River valley refineries.

A considerable mileage of the 26-inch line is of A. O. Smith welded steel line pipe produced in Milwaukee and Houston. We are proud to have contributed to the construction of this, the Biggest Inch, as we have also to virtually every important petroleum products pipe line in the world.

A. O. Smith Line Pipe is available in a complete range of sizes and wall thicknesses, from 8⅝-in. to 36-in. diameters.

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DEPENDABILITY THROUGH RESEARCH AND ENGINEERING

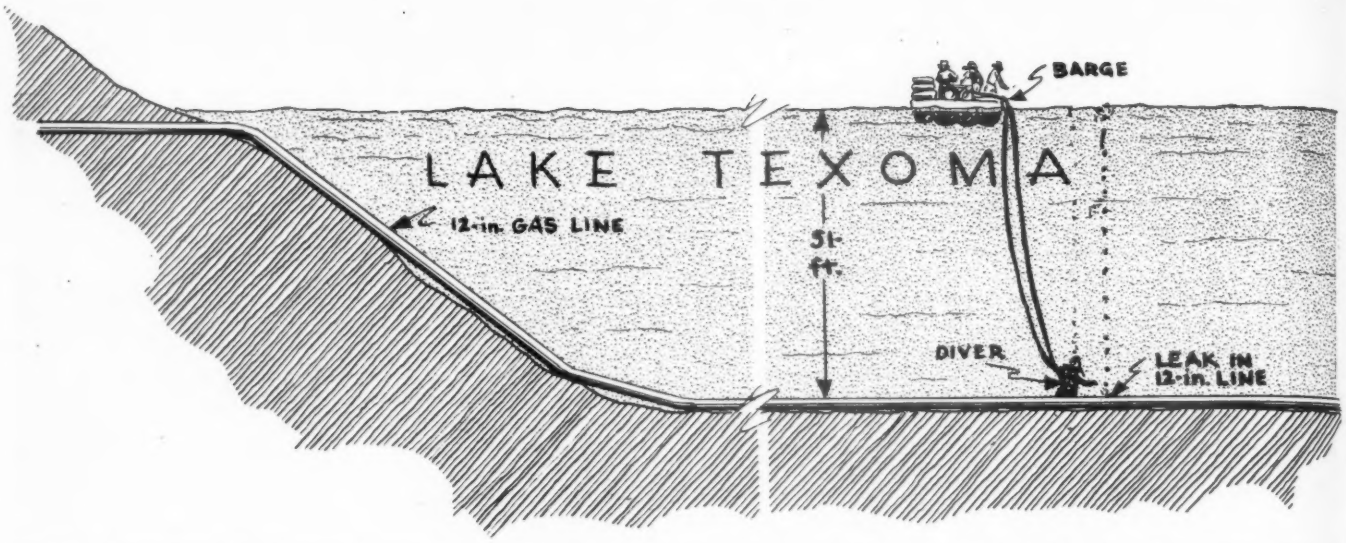

DIAGRAM of underwater repair job on Lone Star Gas Company's 12-in line under Lake Texoma.

BARGE to carry necessary equipment for job was built on lake shore, of 2- by 12-in. planking. The 16-ft square platform was floated on 18 empty oil drums. A winch truck was used to launch barge.

Diver Used to Repair Gas Line Break

Pipeliners called in deep sea diver, built a special barge to repair leak in 12-in. line 51 ft below Lake Texoma surface

CLARIBEL THOMPSON*

A PILOT flying his amphibious plane low over Lake Texoma northwest of Durant, Oklahoma, recently noted an unusual amount of surface bubbling — enough that it justified reporting the attraction to the Army Corps of Engineers who are in charge of the lake.

Little did he realize the excitement it would cause weekend fishermen and unusual activity for Lone Star Gas Company of Dallas, Texas. The surface bubbling was caused by a leak in Lone Star's 12-in. gas pipe line that crosses the old Washita River channel near Durant. At the point of the leak, the line lies 51 ft below the surface of Lake Texoma waters.

In the ensuing events, Lone Star had to call in a deep sea diver and build a sturdy barge from which line repairs could be made.

Originally planning a weld repair on the line, the working platform was loaded with a 300-amp welding unit in addition to the diver's apparatus. A 200-amp welder brought in earlier had been considered inadequate for the job. Gear on the barge also included a small water pump and a borrowed fire hose, which was to be used to "wash" a 6-ft working bell hole around and beneath the line so that the diver could perform the weld.

The diver reported about 4 ft of sand and silt covered the pipe line in the vicinity of the leak. After removing this with the water pressure, he found it impossible to wash sufficient space beneath the line to get at the break, which was on the underside.

Plans to weld the break were abandoned and it was decided to put a split sleeve over the leak. After nearly four hours, the diver was able to finish clamping the sleeve in place, which Lone Star engineers considerd adequate for the repair job. The sleeve has rubber seals and is gas-tight.

The Texoma repair work was super-

*Editor, *Blue Blaze*, Lone Star Gas Company, Dallas, Texas.

EXCLUSIVE

MOTORBOAT, left, was used to tow barge to a spot directly over line break. Equipment for diving operations was already in place with exception of welding unit which they planned to pick up later. Unit was not needed, however, after decision was made to install split sleeve instead of welding the line rupture.

PRELIMINARIES, below, to starting repair work included checking water pump, right, which pumped water through borrowed fire hose for use in washing silt and sand from pipe, and getting diver dressed in his diving gear.

WATER pump, below, is checked during the "washing" operation. Plans to weld the break were abandoned after diver could not flush out a bell hole large enough to permit access with welding equipment to the break on the underside of the line.

DIVER Hubert Crouch, bottom right, comes up from first "trip" below in which he inspected break to determine what materials were needed. First dive consumed an hour, second dive took four hours to complete repair work.

vised by E. K. Smith, Lone Star district pipe line foreman, with only a small crew of men assisting in the operation. Most line crews have access to a boat and outboard motor, and this equipment along with a winch truck was the first to be rounded up for the job.

To build the barge 2 by 12-in. planking was used to make a 16-ft square working platform. Building it near the lake shore, the crew launched it with a winch truck and floated 18 empty oil drums under the side boards to provide buoyancy. Weight of the platform was sufficient enough to keep the drums in place without fastening. A small metal ladder, by which the diver could be lowered over the side, and the diver's compressor and radio equipment completed the gear.

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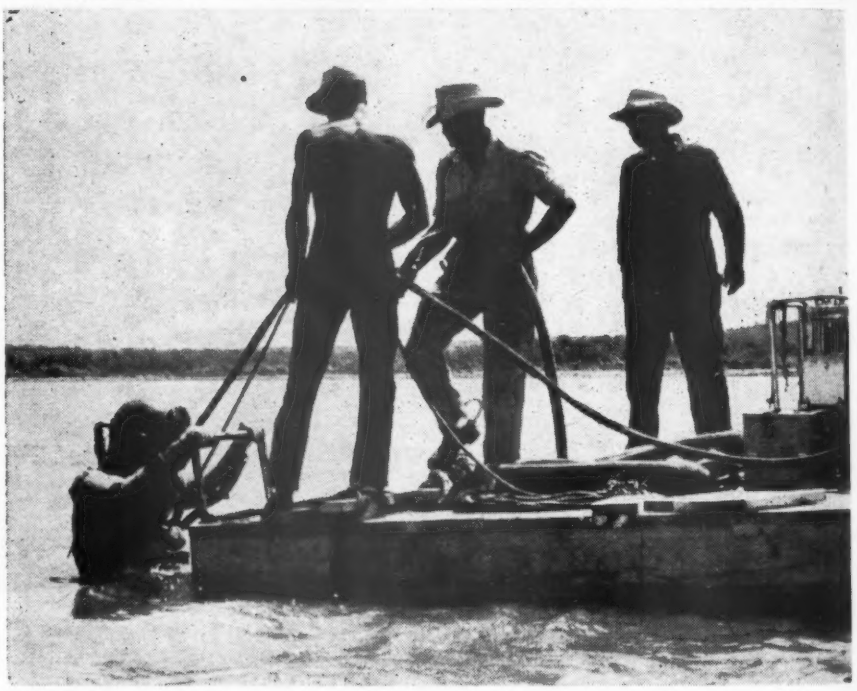

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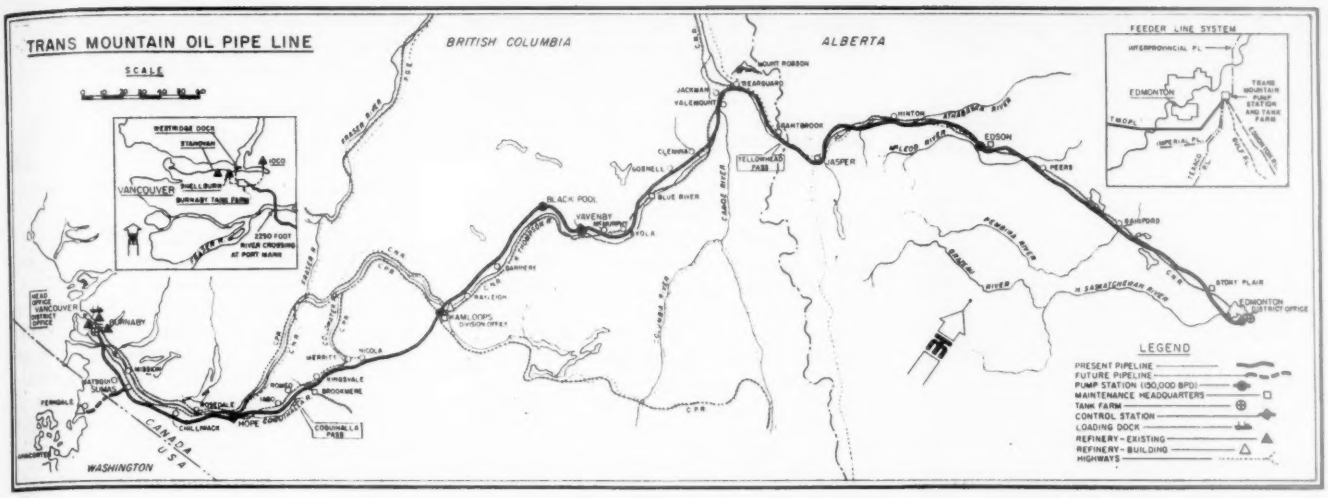

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H. H. ANDERSON

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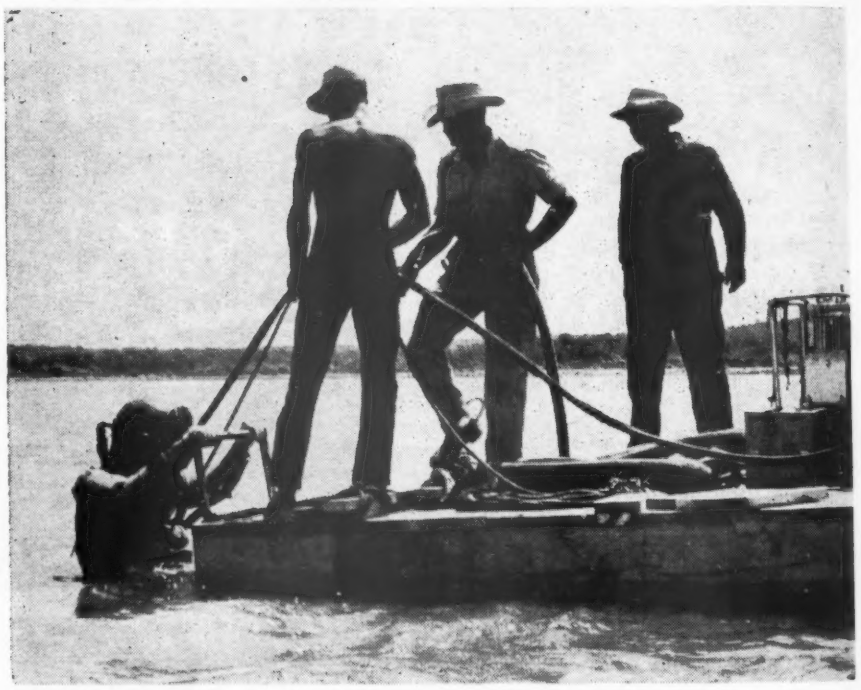

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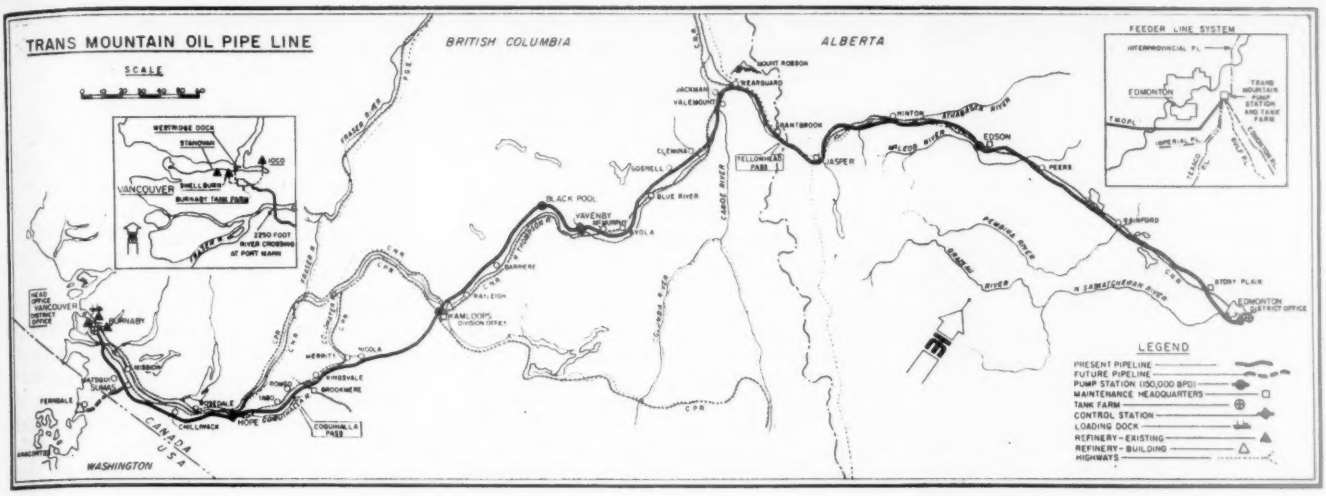

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ELEVATION drops on line, some as high as 3600 ft in 30 miles are result of mountainous terrain and provided designers with numerous headaches.

conveniently loaded for export to more distant consuming areas. In nearby California, the increasing disparity of local production vs demand indicated a market if the Canadian oil could be delivered at costs insuring attractive refinery "net-backs" compared to those of crudes from more distant sources. Moreover, with imports of petroleum products into the Pacific Northwest states exceeding 250,000 bbl daily, it appeared equally obvious that refineries would be built in the Puget Sound area that could be served by a spur line and further insure the economic feasibility of a trans-mountain line.

Company Formed

An extensive study made by Canadian Bechtel Limited determined the best location for the oil pipe line, and its probable capital and operating costs. The study confirmed the economic soundness of the project, and thus Trans Mountain Oil Pipe Line Company, a Canadian company, was formed. The company employed Canadian Bechtel Ltd. to design and engineer the pipe line, and to act as agent for its construction. In this work they were subject to direction by the company's construction committee of oil company engineers and managers.

The company received its Dominion charter on March 21, 1951, by special act of the Parliament of Canada, and was granted on December 13, 1951, a permit by the Board of Transport Commissioners for Canada to construct and operate an all-Canadian crude oil pipe line from the vicinity of Edmonton, Alberta, to the vicinity of Vancouver, British Columbia. A later permit was granted to extend a spur line from Sumas to the Canadian-U. S. boundary in anticipation of pipe line deliveries to Puget Sound refineries.

Route of Line

Topographic maps of a wide area of the Rocky Mountains disclosed only two practical routes between Edmonton and Vancouver — one an international route south from Edmonton through Crows Nest Pass and via Spokane and Seattle, and the other an all-Canadian route east from Edmonton over Yellowhead Pass and through British Columbia. These two routes were inspected by airplane, automobile, and train. Comparative estimates of construction and operating costs indicated clearly that the all-Canadian route over Yellowhead Pass involved the lowest costs, and would require a smaller tonnage of steel — that was then in short supply.

The Yellowhead route was traversed in detail by experienced engineers and construction men. Aerial route photographs were taken and studied under stereoscope. The route finally selected not only is the shortest practicable, with 718 miles of main line, but also it provides minimum elevation and maximum accessibility. Yellowhead Pass is at an elevation above sea level of only 3720 ft, 720 ft lower than Crows Nest, and only 1400 ft higher than Edmonton. A second high of 3900 ft elevation is traversed on the plateau south of Kamloops, B. C., and the crossing of the Coast Range at Coquihalla Pass is at only 3760 ft.

All but approximately 55 miles of the Yellowhead route parallels a transcontinental railway. Over the first 510 miles from Edmonton to Kamloops it follows the Canadian National. Then, after crossing an open plateau for 55 miles, it follows the Canadian Pacific for 67 miles. The last 86 miles more or less follow the Canadian National through settled communities with a network of highways and secondary roads. The route traverses in turn 50 miles of wheatland; 200 miles of rolling timber country; 398 miles of mountains, valleys, plateaus and canyons; and 70 miles of farmland.

Hydraulic Problems

Special hydraulic problems are encountered between Yellowhead and Kamloops where the elevation drops 2600 ft in 300 miles, and down the Coquihalla Pass where it drops 3600 ft in 30 miles. Although most of the line is through mountainous terrain, apart from the Coquihalla Pass and a few other critical places, the location is reasonable for construction of a pipe line. The route is not without its challenges to the operator, however, as it has 72 stream and river crossings; and two 80-mile stretches along the railways have no roads worthy of the name, and they receive from 30 to 50 feet of snowfall each winter!

In addition to the 718 miles of main line, which includes 2½ miles of dock line from Burnaby to Westridge, the project includes a 5½ mile spur line from Sumas Junction to the International Boundary.

The paper work of clearing the right-of-way survey was perhaps more difficult than the field work, as evidenced by the need to distribute an average of 35 copies of 765 maps in order to obtain the necessary 60-ft right-of-way. Easements were obtained from approximately 3000 land-owners — private, municipal and government. About 56 highway crossings and 24 crossings of two railways each presented special problems. The easements bound Trans Mountain to pay damages caused by construction and maintenance of the pipe line. Merchantable timber on the right-of-way was valued by registered appraisers for sale or other disposal.

Design of Line

At the outset two alternative diameters of pipe, 20-in. and 24-in., were considered for the line. The first decision was to construct a 24-in. line with two pumping stations (at Edmonton and Kamloops) to provide an initial capacity of 75,000 bbl daily. With the continued discovery of new oilfields, it was later decided to include a third

AERIAL view of pump station and tank farm at Edmonton, Alberta, terminal.

pump station (at Edson) to handle 120,000 bbl daily, and early in 1953 a fourth station (at Black Pool) was authorized for 150,000 bbl daily.

Redwater crude oil at 40 F was selected as a basis for the hydraulic design of the line. Redwater is a 35-gravity crude with a viscosity of 115 seconds Saybolt at 40 F. An equation was used for computing friction loss in which the value of f was checked with experience recorded on large-diameter pipe lines. Theoretical losses thus calculated were later checked against experience with the Interprovincial pipe line, and were found to be conservative.

The design finally developed was based on use of six stations to deliver 200,000 bbl daily. Their locations were selected with delivery pressures differing to take advantage of local differences in elevation and, through use of tapered sections between stations, to obtain a minimum total pipe tonnage consistent with a minimum wall thickness of 5/16-in. in the mountains, and ¼-in. east of Jasper Park and in the Fraser Valley.

Line Pipe

The line pipe used was made from 52,000 psi yield strength, open-hearth steel, electric-fusion welded, hydraulically expanded, and tested in accordance with API Specification 5LX. Its chemical properties are as given:

Per Cent	Material
0.30	Maximum carbon
0.75 to 1.25	Manganese
0.045	Maximum phosphorus
0.05	Maximum sultur

In the design, the upper value of transverse yield strength was limited to 75,000 psi in order to avoid special welding problems in the field. The maximum allowable design working pressure was based on 65 per cent of nominal yield strength, which is 52,000 psi for ⅜-in. pipe and thinner, and 48,000 or 46,000 psi for heavier pipe, with a 10 per cent minus tolerance on nominal wall thickness.

The pipe is buried throughout the route to safeguard it against damage by landslides and snowslides, and also for insulating the oil against low temperatures that would congeal and deposit excessive wax in the line. Only one exposed span is in the line, where a narrow deep canyon made a buried crossing impracticable. The only expansion provisions are slack loops placed in the line when it was lowered into the ditch.

The normal cover is 30 in., but in rocky areas, the cover is reduced to 24 in. (Only about 5 per cent of the route was rocky enough to require blasting). On the prairie, where severe winter temperatures are common, a 36-in. cover is provided. Corrosion is considered a minor problem, particularly on the western slopes, but the line is coated and wrapped throughout with coal-tar primer, coal-tar enamel, glass fibre and impregnated felt.

Cost of Project

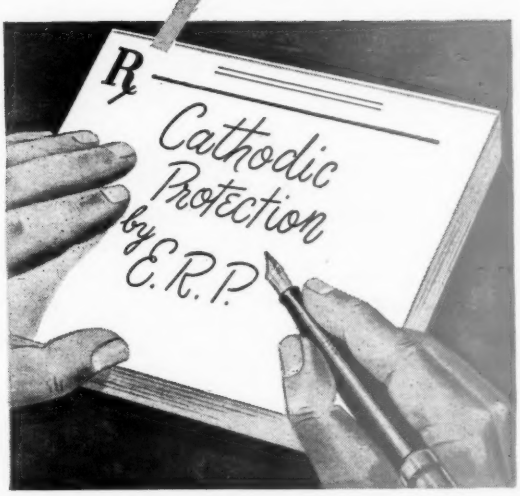
When the Trans Mountain project was first financed, a sum of about $80,000,000 was obtained by sale of bonds and shares to cover the estimated cost of a two-station line of 75,000 bbl daily capacity extending from a then-proposed terminal at Acheson, Alberta, to the terminal at Burnaby, British Columbia.

Later decisions were reached to originate the line 19 miles farther east at East Edmonton, Alberta; to raise the daily capacity to 150,000 bbl daily by adding two pump stations and increasing the numbers of pumps in original stations and the numbers of tanks in the two terminals; to build the marine loading dock in Vancouver Harbor; and to build the spur line from Sumas Junction to the International Boundary. These with minor other additions increased the total estimated cost to $93,000,000. A review of actual costs indicates that the work originally projected was completed approximately within the original estimates.

Line Construction

The majority of the main line location surveying was completed in September, 1952. Some time prior to this, the contracts for the 24-in. pipe were let to Consolidated Western Steel Corporation, Kaiser Steel Corporation and A. O. Smith Corporation. Mileages and tonnages provided by each were: Consolidated Western — 414 miles or 85,000 tons; Kaiser — 274 miles or 55,-

℞ FOR CORROSION...



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000 tons; Smith — 43 miles or 10,000 tons. On March 31, 1952, the first 16 carloads of pipe crossed the border into Canada en route from the Consolidated's Mill at San Francisco.

Comstock Midwestern, Ltd., and Mannix, Ltd., were originally selected as prime contractors to lay the line. Mannix was given approximately 226 miles of line between Blue River, British, Columbia, and Juliet, British Columbia, in the Coldwater Canyon near Coquihalla Summit. The remainder of the line was to be built by Comstock Midwestern.

A tentative construction schedule calling for approximately 300 miles of completed pipeline in 1952, was prepared and released on December 29, 1951. Four pipelaying spreads were to work in 1952, the first starting in the vicinity of Vavenby, British Columbia, and working east towards Blue River; a second beginning at Grantbrook, British Columbia, and working east; a third beginning at Grantbrook and working west; and a fourth beginning at Cheam Lake, British Columbia, working west. The first actual construction work began on February 27, 1952, when clearing and grubbing got under way at Vavenby in the Mannix portion of the line. Grading by Mannix started March 8 working eastward from Vavenby. Comstock Midwestern moved a composite clearing and grading crew in at Jasper March 18. Campbell-Bennett Ltd., clearing and grading sub-contractors for Comstock, moved into Burnaby late in March.

Schedule Revised

Of necessity, the original schedule was revised several times through the 1952 season. Alternate pipe-laying schedules were developed and were reviewed daily during the steel strike in the United States so as to best utilize available pipe. In April, it was decided to add a fifth spread to work eastward from Acheson, Alberta, and lay the 19 miles to the Edmonton terminal. This contract was let to Canadian Pipeline Construction Company, Ltd. It was also decided that Comstock Midwestern's Fraser Valley spread should work eastward towards Hope, B. C., so as to be in a more favorable position to begin construction of the difficult Coquihalla Canyon section in the spring of 1953.

Comstock Midwestern's Grantbrook west spead completed its assigned 65 miles of construction on October 7, 1952, but had to remain in the field to install two Fraser River Crossings. The remaining two Comstock Midwestern spreads shut down in mid-November, the Grantbrook east spread having completed 113 miles of pipe, and the Fraser Valley spread 38 miles. Canadian Pipeline completed its 19 miles between Edmonton and Acheson in November. The Mannix spread continued to work westwards towards Kamloops, British Columbia, until mid-December, at which time it had laid 94 miles of pipe.

1952 Good Year

The 1952 accomplishments in total were very substantial. The entire 718 miles of the main line were located, and legal surveys were completed on all but 8 miles. Easements over 485 miles of right-of-way were acquired and, of the balance, 195 miles were over Crown Lands. There were 329 miles of pipeline laid, including 50 river crossings, 56 highway crossings and 24 railroad crossings. Major river crossings completed in 1952 included the Athabaska (by Comstock Midwestern), Sasketchewan (by Canadian Pipeline), Pembina (by Comstock Midwestern), and McLeod (by Comstock Midwestern). The Thompson River crossing at Kamloops was completed by Mannix in February, 1953.

Early in 1953, a speed-up program was developed. It was arranged that Mannix would work two spreads in 1953. A main spread was to work west from Kamloops and a smaller spread was to close the 50-mile gap east of Kamloops. To assist the speed-up program, Comstock Midwestern relinquished the easterly 53 miles between Acheson and the Pembina River, and contract for construction of this section was made with Anderson International Contractors, Ltd.

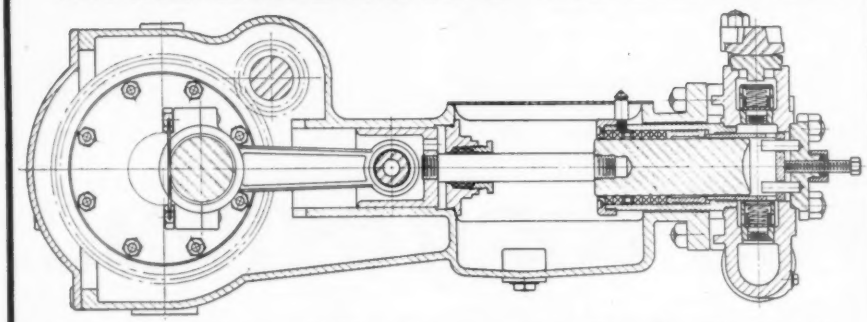
Fraser River Crossing

Missouri Valley Canadian, Ltd., undertook to lay the 2250-ft Fraser River

A New Improved Triplex Pump

POWERED By An *Air-Cooled* HEAVY DUTY

WISCONSIN ENGINE



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FEATURES:

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2. Internal heavy constructed reduction gears operating in an oil bath with shafts on large Timken bearings. Suitable for 1800 RPM prime mover.

3. Outside packed.

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5. Adjustable piston glands with conventional packing on power end that eliminates contamination of lubricating oil.

POWER:

Units fully fabricated with WISCONSIN Air Cooled HEAVY DUTY ENGINES.

SERVICE:

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STOODY 1027 is ideal for manually hard-surfacing large bulky parts too heavy to position for down-hand welding. Typical uses: tractor rollers, bucket sides, drive sprockets, top carrier rolls, idlers, tumblers, track pads, clutches, clevises, sheaves, grousers, gear teeth, etc.

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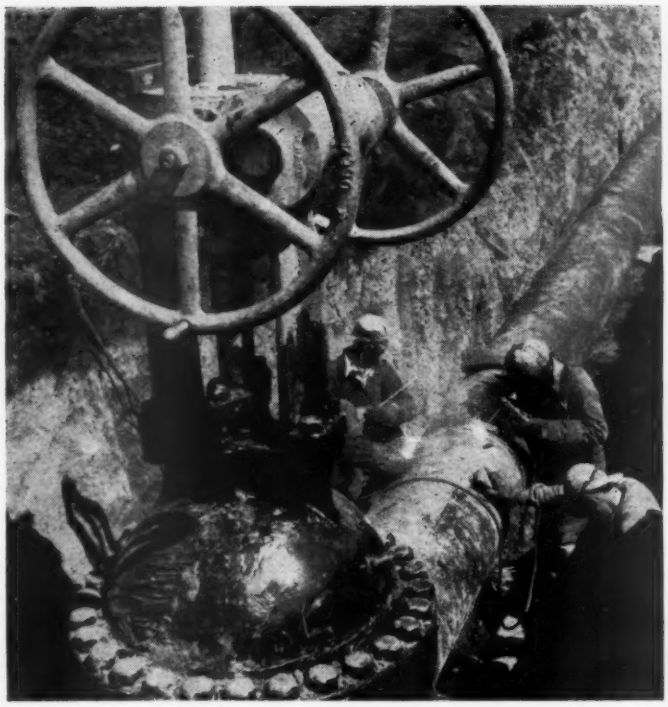
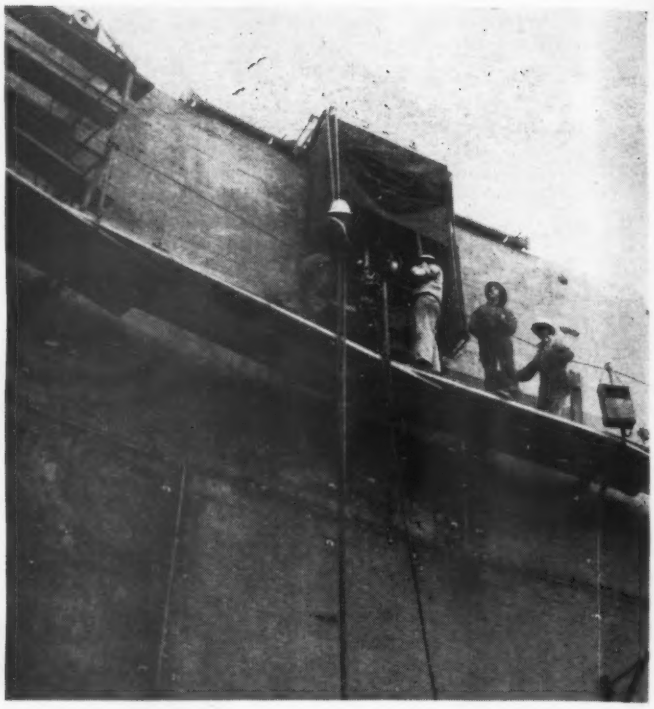


GATE valve near highway about 40 miles west of Edmonton terminal.



TANK construction at Burnaby, using automatic union-melt machine.

The Author

One of the reasons Trans Mountain Oil Pipe Line Company is fast becoming widely known in the pipe line industry is H. H. Anderson, Trans Mountain's vice president and general manager. "Hal," as he is known to his friends, joined Trans Mountain in 1952 after retiring as vice president and general manager of Shell Pipe Line, a post he held from 1941.

After receiving a BS degree in electical engineering and an MS degree in physics and mathematics, Anderson joined Shell as an engineer in the Coalinga field in 1917.

crossing at Port Mann. This crossing was extremely difficult because of tides, surface traffic, unfavorable weather and numerous other troubles. Two sets of welded pipe were prepared for movement to the channel by dollies mounted on a narrow gauge railway. Two winches, each with a rating of 250 tons straight pull, were placed on the south shore. On March 6, 1953, the first pull was begun. The weld was made, enamel, coat and wrap, and concrete were applied, and the second pull was completed March 7. This contractor later laid the 2½ miles of 24-in. line from Burnaby tank farm to Westridge loading dock.

The first Mannix spread to lay pipe in 1953 started at Kamloops on March 9, in a westerly direction toward Merritt. Comstock Midwestern's Fraser Valley spread spent the spring installing pipe on highway lands west of Hope. Its eastern spread commenced pipe laying on May 2; that of Anderson International started west from Acheson on May 21 and Comstock Midwestern's third spread started east from Blue River on June 3.

Mannix completed its section of the line, with the exception of the Nicola River crossing, on June 29. Anderson International and Comstock Midwestern welded out to the Pembina River early in August. The latter's Blue River spread completed tying-in on August 20. This completed pipe laying from Edmonton to the western limit of the Mannix spread, a distance of some 593 miles. One Comstock Midwestern spread completed the Coquihalla Canyon on September 28, and a second closed the 25-mile gap from Burnaby to the 1952 construction on September 30. Comstock Midwestern will lay the 5½-mile spur line from Sumas Junction to the International Boundary during 1953.

A summary of the total statute miles of pipeline laid by the several contractors is: Comstock Midwestern, Ltd., 417½ miles; Mannix, Ltd., 226 miles; Anderson International Contractors, Ltd., 53 miles; Canadian Pipeline Construction Company, Ltd., 19 miles; Missouri Valley Canadian, Ltd., 2½ miles (dock line).

Pump Stations

The locations of the four pump stations are "Edmonton" — six miles east of Edmonton, Alberta; "Edson" — nine miles west of Edson, Alberta; "Black Pool" — 70 miles north of Kamloops, British Columbia; and "Kamloops" — four miles west of Kamloops.

All main station pump houses are 140 ft long by 65 ft wide. They are of similar design, having rigid steel frames, corrugated transite gable roofs and concrete block sides. Exterior finish is light green stucco. Interior wall finish is light-buff and the ceilings are steel pan acoustic tile laid over 2-in. fibre-glass batts. Each pump house contains an engine room, a pump room, a fuel preparation room, control room, a boiler room, a storeroom and a washroom. The engine and pump rooms — initially constructed long enough to house four main pumping units for 200,000 bbl daily capacity — are separated by a vapor-lock concrete-block fire-wall, and both are provided with overhead cranes. Each station has also a 50-ft by 30-ft auxiliary building containing a fire-pump room, a three-bay garage and small heater room.

Pumping Equipment

All stations are equipped with engines driving centrifugal pumps through speed increasers. Edmonton station is equipped for "parallel" pump operation. It has three supercharged, 8-cyclinder, 1760-hp, 500-rpm engines operating principally on natural gas. These are direct-coupled to speed increasers having 1.0 to 7.6 ratio. A pedestal bearing is installed between the engine and the fire-wall. The speed increasers are direct-coupled to 8 x 10 five-stage centrifugal pumps. The main units at Kamloops station are similar except that the engines are equipped only for liquid fuel. The Black Pool station, to be completed in December, 1953, will contain equipment similar to that at Kamloops.

Edson station is equipped for "series" pump operation. It has three supercharged, 6-cylinder, 1320-hp, 500-rpm engines direct-coupled through the fire wall to speed increasers having 1.0 to 8.2 ratio. These are

coupled to type 10 x 12 single-stage centrifugal pumps. Future stations at Gainford and Jasper (to accommodate 200,000 bbl daily throughput) will be similarly arranged for series pump operation.

Operating Capacities

With one unit each operating at Edmonton and Kamloops, the line has a capacity of 75,000 bbl daily. This may be increased to 120,000 bbl daily by operating two units each at Edmonton, Edson and Kamloops. To increase the capacity to 150,000 bbl daily, two units operating at each of the four stations including Black Pool are required. The third units at each station serve as standbys.

Much study was given to the comparative merits of parallel and series arrangements of the station pumping units. It was finally determined that the parallel arrangement was more economical for the high static head conditions encountered at Edmonton, Black Pool and Kamloops, and that series arrangement was more suitable for Edson, and later for Gainford and Jasper.

For example, at Edmonton, with a throughput of 120,000 bbl daily the static lift will be about 45 per cent of the total pumping head. Similarly, at Kamloops, the static lift will be about 65 per cent. Under such conditions parallel unit operation is of distinct advantage because flows up to 75,000 bbl daily can be handled by operation of a single unit.

If series units had been installed, two of them would have to be operated either throttled or at reduced speeds and at greatly reduced fuel efficiency. The line's actual throughput demand could not be predicted closely, and it was economical to install station equipment in rather large increments, thus the parallel pumping units at the high static lift stations offered the most economical and flexible arrangement.

Automatic Controls

Although the line flow can be manually controlled with the station tanks floating on the line, three types of automatic engine control devices at stations are being provided:

(a) one group, sensed by unit flow meters, will equally distribute the load between the "parallel" pumping units.

(b) another group will maintain station intake and discharge rates in synchronism.

(c) a third group, including "Tivy Boxes," will permit automatic placing or substitution of pumping units into service.

Fuel Supplies

Crude oil for engine fuel is drawn off the main line and gauged into station tanks. It passes through a settling tank and heater into a centrifuge whence it is run to a pure fuel tank for engine supply. The pure fuel tank is in the fuel preparation room where it is kept at normal temperature.

At Edmonton, the diesels operate as dual-fuel engines, using five per cent liquid fuel and 95 per cent fuel gas purchased from Northwest Utilities, Ltd. The main gas supply is received through a regulator at 60 psi. It passes through a scrubber at that pressure to the fuel gas header. At each engine it then flows through a low-pressure supply regulator, and a safety shut-off valve controlled by engine fuel-oil pressure.

Electric Power

Each station has about 30 electric motors driving auxiliary equipment. Electric power supply for their operation at Edmonton and Kamloops is purchased from public service companies — Calgary Power, Ltd., at Edmonton, and British Columbia Power Commission at Kamloops. Standby power supplies have been installed at both stations in the form of engine-driven generator sets. The unit at Edmonton is equipped to operate on natural gas, and that at Kamloops on diesel fuel. Electric power at Edson and Black Pool stations must be generated locally, thus slower-speed crude-oil-burning, diesel-driven units are installed in duplicate, one being sufficient to carry the load with and the other serving as a standby.

Station Heating

Each station has two heating systems: (1) forced-circulation hot-water

PIPELINE SPECIALTIES

WITH THE MARK OF APPROVAL

H & S Selinium Rectifiers

Lion E-120 Asphalt Pipe Enamel

Coke Breeze

Lion Cold Applied Pipe and Tank Coating

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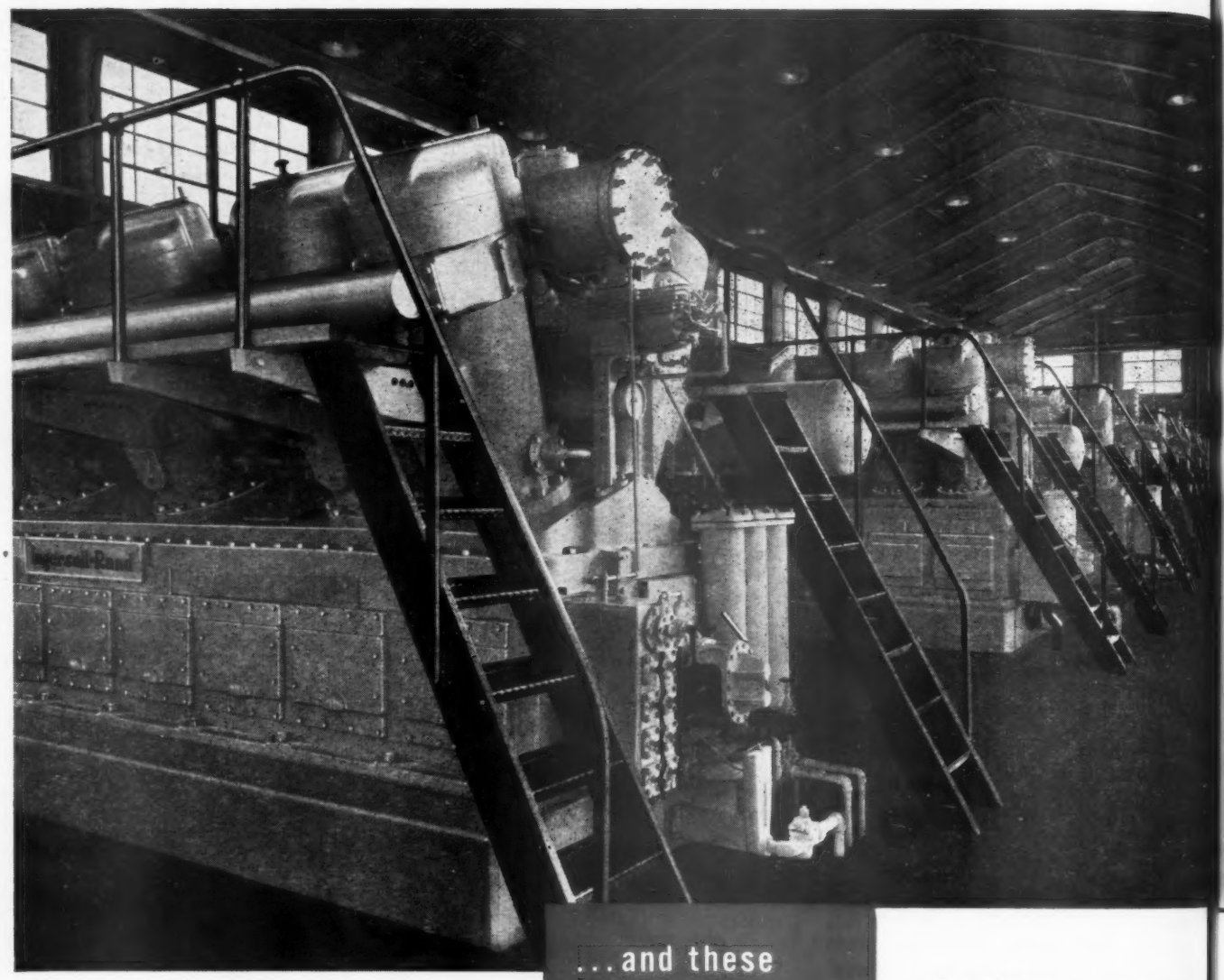
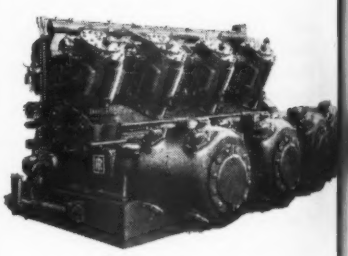
Holcombe & Stearns INC.
POST OFFICE BOX 1306
SHREVEPORT LOUISIANA

TWELVE I-R KVG GAS-E

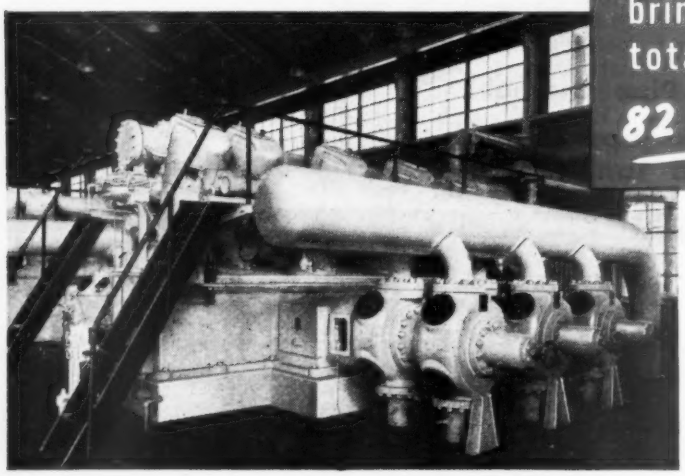


Six Ingersoll-Rand KVG gas-engine-driven compressors installed at United Gas Pipe Line Company's new Needville, Texas, gas booster station. These 1320-hp units boost gas pressure to 900 psig on a new 30-inch line.

...and these OTHER I-R compressors and gas engines bring United's total to *82 MACHINES!*



35 XVG's



Another view of the six KVG compressors at United Gas Pipe Line Company's Needville Station showing the compressor cylinders. This installation is duplicated at the Goodrich station.

COMPRESSORS • DIESEL AND GAS ENGINES •

ENGINE-DRIVEN COMPRESSORS

add 15,840 hp to rapidly expanding natural gas system of

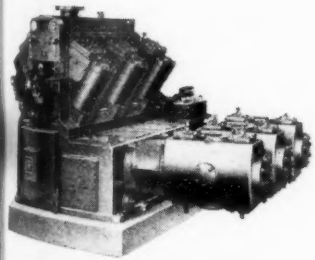
United Gas Pipe Line Company

It is a privilege to serve those who serve the Nation. Hence Ingersoll-Rand takes justifiable pride in the recent installation of twelve KVG gas-engine-driven compressors by the largest handler of natural gas in the world. These 1320-hp units, installed in booster stations at Needville & Goodrich, compress natural gas to 900 psig on a new 30-inch line – part of United's continuing program of system expansion.

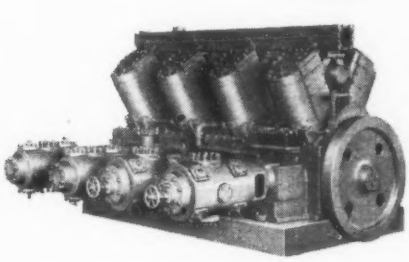
Ingersoll-Rand equipment is well known to operators throughout the entire United Gas Pipe Line system. For United has been using I-R compressors and engines for the past sixteen years.

The first of the famous XVG compressors were installed in 1937. Subsequent installations brought United's total to thirty-five of these XVG units – the original V-angle design pioneered by Ingersoll-Rand. Also included on the United Gas Pipe Line system are twenty-three of the newly-acclaimed JVG and SVG compressors, superseding the original XVG design – fourteen JVG units in 110, 165 and 220 hp sizes, and nine SVG units in 330 and 440 sizes. In addition, twelve 408-hp PVG gas engines have been installed for serving their pipe line stations.

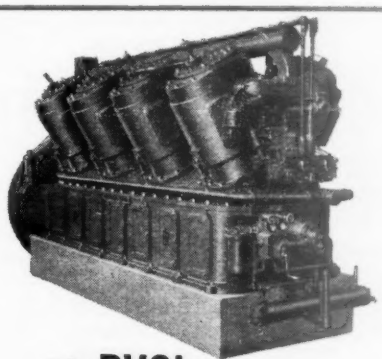
All of these compressors and gas engines are now in operation, giving the continuous dependable service for which I-R equipment has become traditional throughout the gas industry. Your nearest Ingersoll-Rand representative will be glad to give you complete information on I-R V Four-Cycle gas-engine-driven compressors in any type or capacity.



14 JVG's



9 SVG's



12 PVG's

956-6

4 CYCLE V

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11 Broadway, New York 4, N. Y.

• AIR TOOLS • ROCK DRILLS • TURBO BLOWERS • CENTRIFUGAL PUMPS • CONDENSERS

SCHEMATIC diagram of Trans Mountain line facilities.

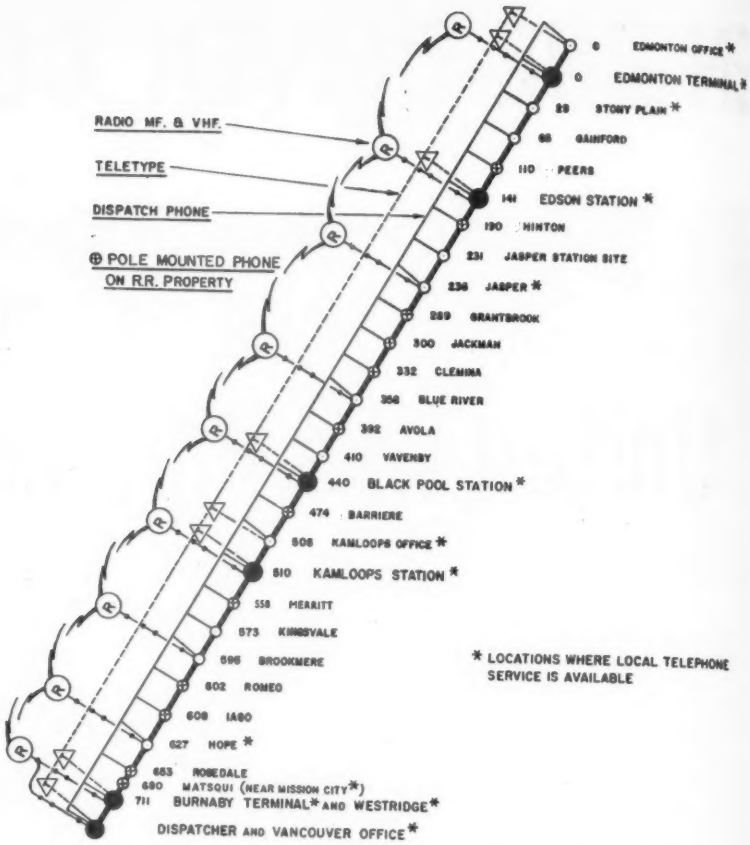


DIAGRAM of Trans Mountain's communications network.

heating in the main pump house, and (2) gravity-return steam heating in the combination garage and fire-pump house. The water in the pump house system is heated by either exhaust-silencer waste-heat boilers or auxiliary crude-oil-fired boilers of 1,000,000 Btu per hour capacity. Two of the engines operating near full load will generate sufficient heat for the waste-heat boilers to warm the pump house in the coldest weather. Operation of these boilers is automatic. Under light engine loads in cold weather, however, the oil-fired boiler, manually started, operates automatically with an induced-draft fan working through a time relay. The steam for each auxiliary building is generated in a diesel-oil-fired boiler operating at 2 psi under automatic electric control.

Station Contractors

The pump stations at Edmonton (including terminal piping), Edson and Kamloops were built under general contract by Mannix, Ltd., and that at Black Pool by Marwell Construction Company, Ltd. Installation of the main pumping units, comprising the engines, speed increasers, and pumps, was done under supervision of representatives of Nordberg Manufacturing Company.

Pressure-Limiting Stations

The first pressure-limiting station is located at Vavenby which is 165 miles west and 2100 ft lower than Yellowhead Pass. An automatic valve at Vavenby will shut to insure that static head down-stream to the Thompson River crossing at Kamloops (elevation 1120 ft) shall be reduced by 650 ft to a safe head of 2160 ft.

The other, a pressure-relief station, is situated at Hope, elevation 210 ft, which is about 30 miles west of the 3760 ft summit of Coquihalla Pass. Here a battery of relief valves can spill oil into two 50,000 bbl tanks so that the pressure in the pipe from Hope to Burnaby may be reduced to limits of safety in case of accidental closure of a valve against the main line flow.

Use of this pressure-limiting equipment saved about $5,000,000 in the original line investment by avoiding need for heavier-wall pipe to withstand high pressures during accidental shut-offs in the low sections of the system.

Communications

Installation of a microwave radio system was considered, but it was rejected as inadvisable for two reasons: (1) too expensive to install because the tortuous route would require too many repeater towers, and (2) impracticable to main service continuity because two 80-mile stretches of the ruggedest terrain have practically no roads and receive 30 to 50 ft of snowfall each winter.

As a consequence, other communications facilities were provided. These are:

(1) A telephone circuit consisting of a leased specially-installed metallic pair approximately paralleling the pipe line from end to end and connecting about 25 locations.

(2) A leased teletype service connecting about 7 locations.

(3) Company-owned dual-frequency radio facilities, including nine fixed stations and 25 mobile stations, each operating on 2628 kilocycles AM and 165.63 megacycles FM.

The telephone circuit is primarily for dispatching purposes, connecting all pump stations, terminals, maintenance headquarters, and scraper traps, plus a number of emergency sets in pole-mounted boxes at convenient points. The metallic pair is marked on the crossarms to permit use of portable clip-on telephones. It is of interest that no public telephone service is available along 250 miles of the route between Jasper, Alberta, and Little Fort, British Columbia. The circuit was provided by Canadian National Telegraphs. Ringing of all regularly connected instruments from dispatcher's office and from Edmonton station is soon to be made possible by installation of an electronic tone-response ringing system.

The teletype service, taken on a temporary basis to determine its need, connects the offices and pump stations only. It is intended normally for administrative messages, but can be taken over by dispatchers if the telephone circuit fails due to slides or washouts. Although over much of the route the telephone and teletype circuits normally are on the same CNT pole line, the teletype can be routed differently in emergencies.

Primarily to maintain contact with maintenance personnel, but also to further insure continuity of dispatch communication, nine fixed radio sets are located at terminals, pump stations and maintenance headquarters. The 2628

Westinghouse Microwave Letter

WESTINGHOUSE ELECTRIC CORPORATION, ELECTRONICS DIVISION, 2519 WILKENS AVE., BALT. 3, MD.

30 Independent Channels Give Maximum Communications Capacity...Reliability

Many critical communications and control requirements are solved by microwave—the newest complete system of communications. When you compare the practical advantages of presently available microwave systems, consider these facts about the new Westinghouse 2000 MC Microwave.

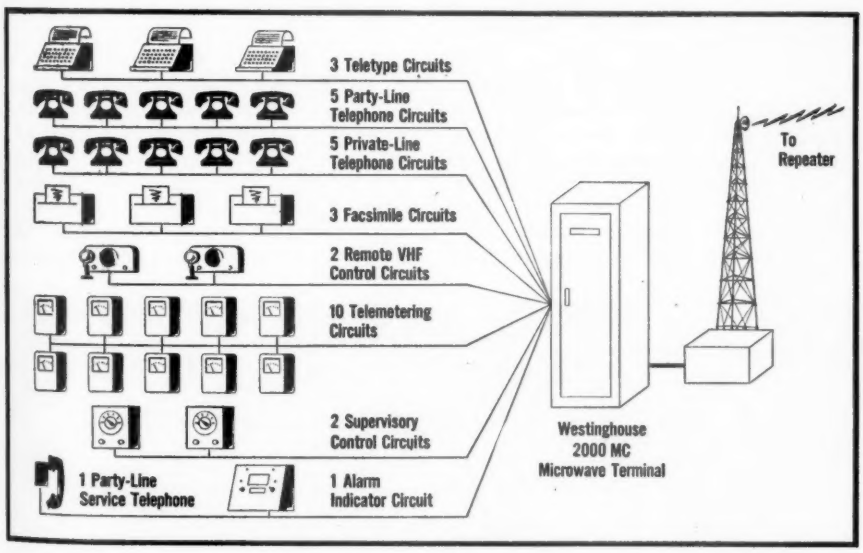
This Westinghouse system is based on (1) an extensive field and laboratory study of user requirements, and (2) years of valuable manufacturing and application experience with all types of end-use equipment. Selection of the 2000 MC band is one important result. This band provides more capacity than lower frequencies . . . gives less fading than higher frequencies.

Another important result is capacity: Westinghouse 2000 MC Microwave supplies 30 voice channels—more than enough for most present needs and capable of accommodating future needs. An independent 31st channel supplies service communications.

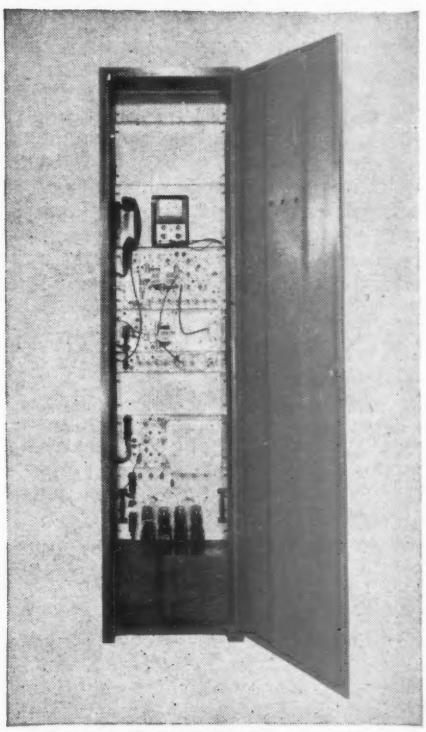
Each of these 30 voice channels can handle up to 15 telegraphic circuits. At full telegraphic capacity, 450 circuits are available for teletype, telemetering, VHF control, supervisory control, relaying, load control, and other functions. See illustration below for a typical arrangement.

These functions of Westinghouse microwave are based on a simple, flexible system of utmost reliability. Its two streamlined assemblies – Type FR Microwave Radio (illustrated) and Type FJ Multiplexing Equipment – have only four basic units each. Type FR Radio units can be assembled as either terminal or repeater stations. Type FJ Multiplex panels are entirely self-contained . . . each panel is provided with an individual power supply . . . and for high multiplex channel stability each channel has individual crystal control.

Strict channel independence like this means multiplexing reliability. If one channel develops a fault, all other channels continue to operate without interruption. That's why Westinghouse multiplex equipment, using frequency division, is your greatest guarantee of service continuity.



One of the many combinations of services that can be operated simultaneously over one microwave radio beam in Westinghouse 2000 MC Microwave radio.



Westinghouse Type FR Microwave Radio assembly. Service channel and alarm panel are included for safe, efficient operation.

Westinghouse has called upon its years of practical experience in microwave communications to suggest other beneficial design features for the new 2000 MC equipment. Call your Westinghouse representative or write: Westinghouse Electric Corporation, Electronics Division, Microwave Section, 2519 Wilkens Ave., Baltimore 3, Maryland.

Ask for our Microwave Booklet

YOU CAN BE SURE...IF IT'S Westinghouse

J-02274

TYING-IN pipe section along swampy right-of-way.

DRILLING operations in Coquihalla Canyon.

kc channel has been found surprisingly effective in piercing the mountainous terrain on a point-to-point basis and with a minimum of manual relaying. The VHF channel is for normal communication with and between the trucks, cars and vehicles, etc.; however, these vehicles carry sets operating in both channels. Walkie-talkie sets function on the VFH for local contacts during crew operations.

Terminals

The major oilfields in the Edmonton area are connected to Trans Mountain's terminal, which is situated immediately west of Interprovincial Pipeline's terminal, by five gathering and feeder pipe lines of other carrier companies. These include lines of The Imperial Pipe Line Company, Ltd. (from Leduc, Golden Spike, and Woodbend); Edmonton Pipe Line Company, Ltd. (from Joseph Lake, Armena and Camrose); Texaco Exploration Company (from Wizard Lake and Bonnie Glen); Canadian Gulf Pipe Line Company (from Duhamel, Malmo, Stettler, Fenn, and Big Valley), and Interprovincial Pipe Line Company (from Redwater and Excelsior).

The Edmonton terminal, situated in a 160-acre tract and subject to rigorous winter weather, contains eight 150,000 bbl and four 80,000 bbl steel cone-roof tanks. The western terminal at Burnaby near Vancouver is situated in a 200-acre tract at an elevation of 495-575 ft above tidewater on Burnaby Mountain. This terminal, in an area subject to milder winters, contains six 150,000 bbl and four 80,000 bbl steel floating-roof tanks. The numbers and capacities of terminal tanks should permit the handling of at least three and possibly four types of crude oil. Those scheduled for receipt as initial line-fill are designated as "Redwater," "Light Mix" and "Leduc." The Burnaby terminal contains a special skimming sump to clean up tank bleedings.

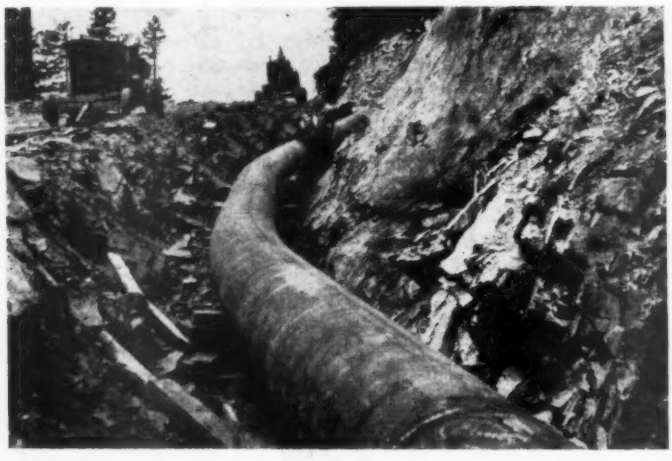
The marine loading dock at Westridge on Burrard Inlet is fed by gravity flow from the Burnaby Terminal through 2½ miles of 24-in. line. Local pipe lines have been privately constructed by Imperial Oil and Shell Oil to connect the tank manifold at Burnaby with their recently modernized and enlarged refineries on Burrard Inlet. Imperial's 12-in. line is 4¼ miles long and includes a 3500-ft crossing under the Inlet. Shell's 10-in. line is 2½ miles long. Both can deliver 50-60,000 bbl daily under gravity flow. Standard Oil Company of British Columbia, Ltd., has announced a proposed modernization and enlargement of its nearby Stanovan refinery, also on Burrard Inlet, and the construction of a private pipe line connecting same to the Burnaby Terminal.

The intermediate pump stations on the line are equipped with one or two 80,000 bbl tanks, those at Edson (on the prairie) having cone roofs and those at Black Pool and Kamloops (in milder areas) having floating roofs. It is contemplated that these tanks will be used only in emergencies to receive line drainage, etc. The general contractor for Burnaby terminal was Marwell Construction Company, Ltd. The grading and drainage work at Burnaby alone cost about $250,000.

At North Kamloops, British Columbia, a take-off has been provided to service the new 5000 bbl per day capacity refinery being erected by Royalite Products, Ltd., which is expected to go "on stream" in late 1953 or early 1954.

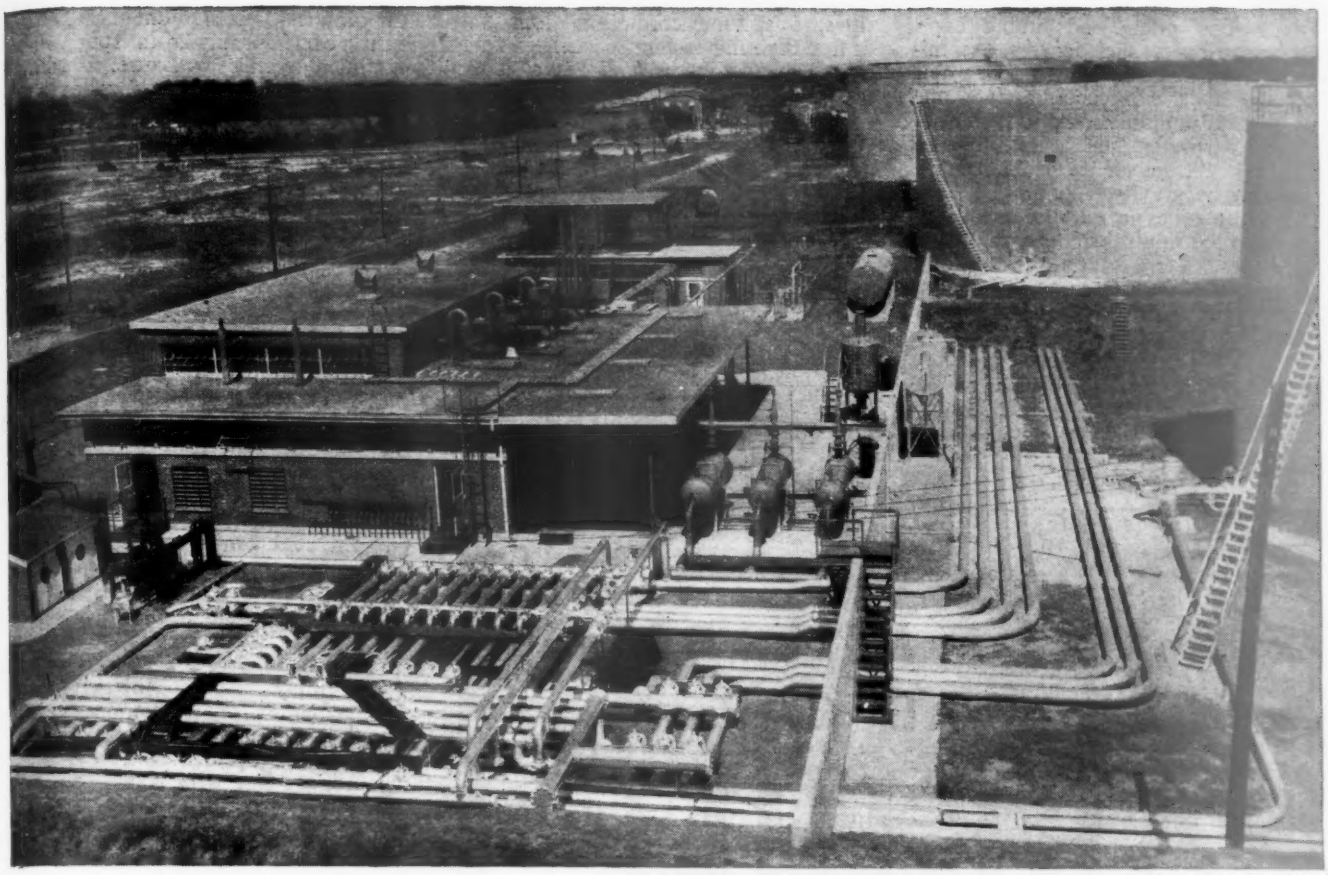
Westridge Dock

The marine loading dock at Westridge is an L-shaped structure. The main pier is 275 ft long, and the dockhead is 150 ft long with 85-ft walkway extensions at each end. Buoyed moorings are located 740 ft apart and 80 ft behind the face of the dockhead. The dock construction is of pressure-creo-



STEEP, rocky ledges increased construction costs.

BATTERY of diesel pumps used for hydrostatic testing.



WORTHINGTON DIESEL-EQUIPPED PUMPING STATION of the Southeastern Pipeline Company at Blountstown, Florida, 30 miles north of Port St. Joe.

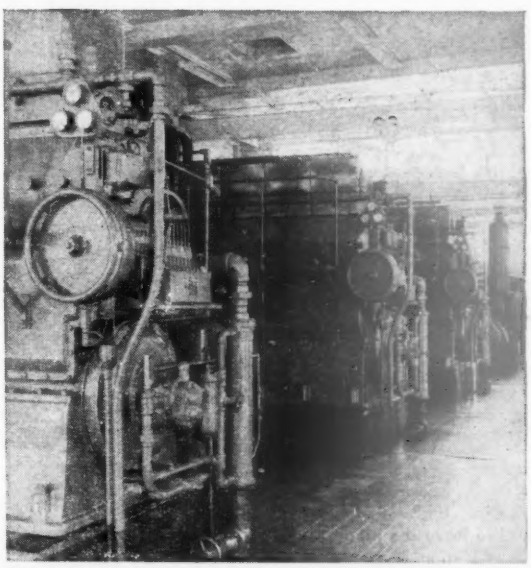
Worthington Diesels give "Eleven years of almost continuous operation"

• That's what the Southeastern Pipeline Company writes about the dependability of their six Worthington Diesels.

The engines are used to drive Worthington pumps which deliver gasoline and kerosene from Port St. Joe, Florida, to Chattanooga, Tennessee. They've been running almost continuously for eleven years with extremely low fuel consumption and maintenance costs.

This company's long satisfactory experience with the dependable Worthington Diesels has been duplicated by pipeline companies everywhere. Learn how Worthington engines, engine-starting compressors, oil transfer pumps, cooling water circulation pumps and evaporative type engine water coolers can help you in your operation too.

Write for more facts to Worthington Corporation, Engine Division, Section E.3.5, Buffalo, N. Y.



IN HEAVY-DUTY OPERATION SINCE 1942, these three Worthington Diesels at Southeastern's pumping station in Blountstown, Florida, and three at Port St. Joe, Florida, furnish all the power for driving the main pumps in these stations.

E.3.5

WORTHINGTON

Economical Continuous Power—Diesel, Dual Fuel, and Spark-Ignition Gas Engines, from 190 to 2100 bhp.

soted wood piling and timber caps, timber stringers and deckers. As initially constructed in the 14-acre water lot, the dock can accommodate one T2 (or smaller) tanker and some barges in the 35-ft water. The 24-in. line from Burnaby will deliver up to 20,000 bbl per hour by gravity. A unique system of friction tubes in parallel is located on shore for control of flow rate. Adjacent on a 9-acre tract are two 10,000 bbl cone-roof tanks for use in changing types of oil in the delivery line, and a 50,000 bbl cone-roof tank and a sump for ballast water skimming. Also provided are the usual oil transfer lines, ballast discharge lines, a fresh water line from shore, fire protection facilities, telephone communications and a floodlighting system. Greenlees Construction Company, Ltd., erected the dock and Marwell Construction Company, Ltd., built the shore facilities.

Ferndale Spur

Provision has been made for delivery of oil by spur pipe line to the 35,000 bbl daily capacity plant of General Petroleum Corporation (a Socony-Vacuum subsidiary) southwest of Ferndale, Washington. This plant is scheduled for completion in late 1954. A 24-in. spur line of Trans Mountain is to take off from the main 24-in line at Sumas Junction, about 70 miles east of Vancouver, and extend 5½ miles to the International Boundary. During spring of 1954, this 24-in. spur will be extended 15 miles to Laurel, Washington, with a 16-in. lateral 11 miles to the Ferndale plant. The total spur distance from Sumas Junction to Ferndale is 32 miles. Sufficient static head exists on the line from Coquihalla Pass (elevation 3760 ft) to gravitate oil at a 200,000 bbl daily rate as far as the Seattle area, thus making installation of break-out tanks at Sumas Junction unnecessary.

Line Pressure Testing

An essential phase of the construction work was the pressure testing of the main line prior to introduction of the oil. Different from those of many recently-built large lines, the Trans Mountain route is subject to the vagaries of prairie, foothill, and mountain fall and winter weather, and the unpredictability of freezing conditions. Thus, when it seemed uncertain that construction would be finished before the 1952-53 winter set in, a decision was reached to pressure-test the line with compressed air. However, after arrangements for September, 1953, completion tests were made and assured, it was decided instead to pressure-test the line with water.

At a conference of engineers representing Trans Mountain, Canadian Bechtel Limited, and the Board of Transport Commissioners, it was agreed that the testing should be done in 18 sections, and that each should be subjected for six hours to a hydrostatic pressure equal to 125 per cent of that to which the pipe would be subjected during normal oil-pumping operations. Later, by common consent, the test periods were extended to 12 hours.

It was arranged that the testing should be conducted by the Trans Mountain organization through its subsidiary, Alpac Construction and Surveys, Ltd. A group of experienced American pipe line maintenance foremen were obtained on loan to supervise the field work, with the results of each sectional test being subject to observation by the engineers of Trans Mountain, Canadian Bechtel, Ltd., and the Board of Transport Commissioners, and approval by the latter.

Seven portable pumping units were purchased for the job, these comprising 10-in. horizontal-duplex piston power-pumps belt-driven by gasoline engines. Five medium-pressure units in parallel could fill the line with water at about 85,000 bbl daily, a rate which moved the trash scrapers ahead at about 1¼ miles per hour. By careful planning, it was possible to fill most of the line with water from only three sources, the North Saskatchewan River, Yellowhead Lake and the Blue River.

Station Units Tested

The station pumping units were given a work-out during three testing activities. Water to fill about 200 miles of pipe line from Edmonton west was the same as that taken from the North

That's Right...
From STEEL MILL, BARGE or RAILROAD CAR...

PARKHILL

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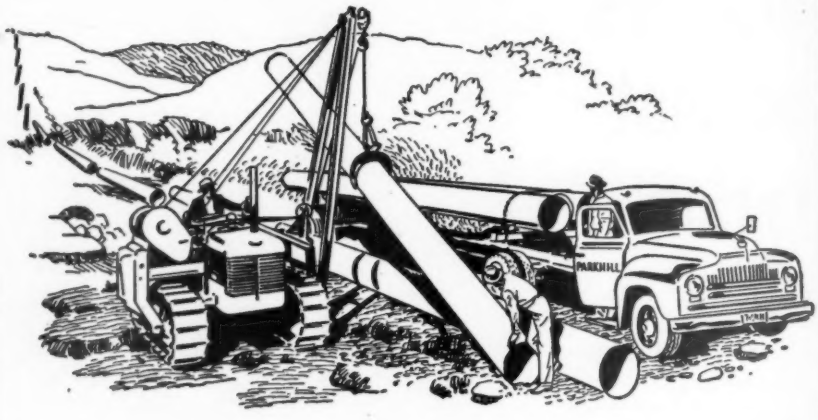

Just "pipe stringing" and "oil field hauling" are only a part of Parkhill service today. We have the modern equipment, experienced organization and trained crews to relieve pipe line officials and contractors of every step in the movement of pipe from steel mill, boat dock or rail yard and place it along the right of way, ready for installation. Next time, put Parkhill on your team.

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This is the pipe dream which Canadian Bechtel Limited made a reality. Known as the Trans Mountain Pipe Line, it is moving crude oil to Vancouver and Seattle areas.

Aiding in the completion of this gigantic project was the dependable delivery of Basalt-Kaiser steel pipe from California—more evidence of how Kaiser Steel is helping to build a stronger West.

This is one more example of Kaiser Steel's dependability—one more reason why experienced pipe line companies know that . . .

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KAISER STEEL PIPE SPECIFICATIONS • All pipe manufactured to latest A.S.T.M. and A.P.I. specifications

Type	Diameter	Length	Wall Thickness	Shipping Point
Continuous Weld—Threaded and Coupled	½" to 4" nominal I.D.	Uniform 21'	Standard	Fontana, Calif.
Continuous Weld—Plain End	2⅜" to 4½" O.D.	Up to 40'	Standard	Fontana, Calif.
Electric Resistance and Fusion Weld—Plain End	14" to 18" O.D.	Up to 40'	.250" to .500"	Napa, Calif.—Basalt-Kaiser
Electric Resistance Weld—Plain End	5⅛" to 12¾" O.D.	Up to 55'	.188" to .375"	Fontana, Calif.
Electric Fusion Weld—Expanded—Plain End	20" to 30" O.D.	Up to 40'	.250" to .500"	Napa, Calif.—Basalt-Kaiser

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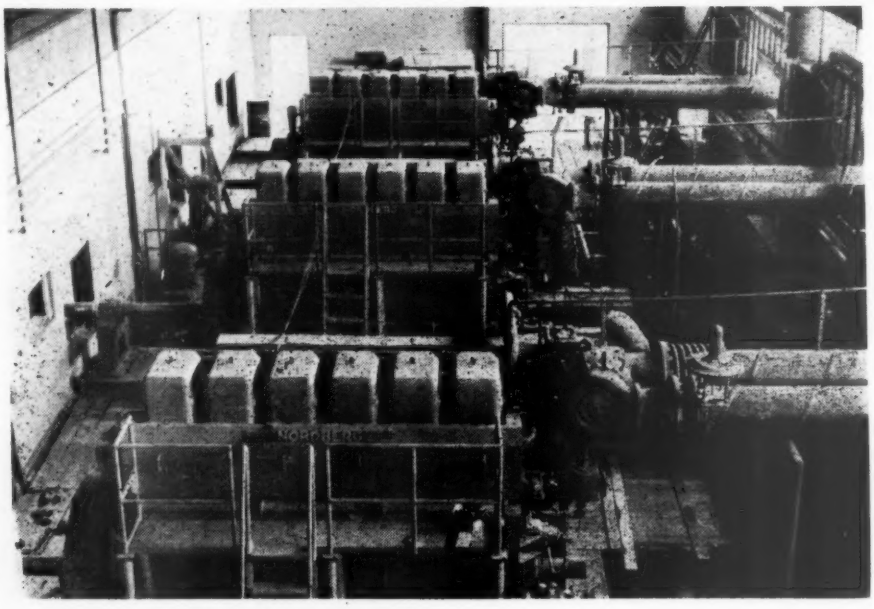
FINAL tie-in of 24-in. pipe at Fraser River.

SCRAPER trap at Blue River, British Columbia.



ENGINE room at the Edson pump station.

Saskatchewan River to test the Edmonton Terminal steel tanks. This water was drawn from the tanks and moved up the pipe line by the Edmonton station pumps. Through use of the station tanks as float tanks, the pumps at Kamloops station were operated in series with the portable pumps (grouped about 145 miles distant) to boost the water from the Blue River southwest over the plateau to Merritt and over the Coquihalla Summit.

After each section was filled with water, the pressure was raised to the prescribed test limit by a high-pressure unit, referred to as as "squeeze pump." The availability of two such units permitted test work simultaneously in two areas. The highest pressure required was in the section just south of Kamloops station, which was tested to 1425 psi. In this phase of the work, careful planning permitted as many as three sections, each requiring successively lower test valves, to be pressured from a single setting of a squeeze pump which, of course, had to be located at a water source. Except for leaking valve-bonnets or flanges, most of the sections tested "okay" at the outset. The very few other leaks encountered were principally small cracks at the ends of mill pipe welds.

Small Leaks Big Problem

The finding of small leaks during the water-test presented quite a problem through sandy terrain where small stream crossings were frequent. These sections, too, occasionally were situated where access and travel was most difficult. Especially useful were the four sonic leak detectors on the job. These operate on the principal of amplifying the highpitched noises of the escaping water. As an operator said, "They are so sensitive we can hear bees flying by!"

One leak, which occurred in a roadless 28-mile section above Blue River where surface water run-off and rain was prevalent, took exactly three weeks to find. The water was leaking at about 12-15 bbl per hour, and the escape was not visible. General rain prevented effective use of the sonic detectors. After some time spent in foot patrol, a non-toxic fluorescent dye was obtained that shines at night under infra-red light. Recharging and repressuring the section with a heavy solution of this dye proved futile.

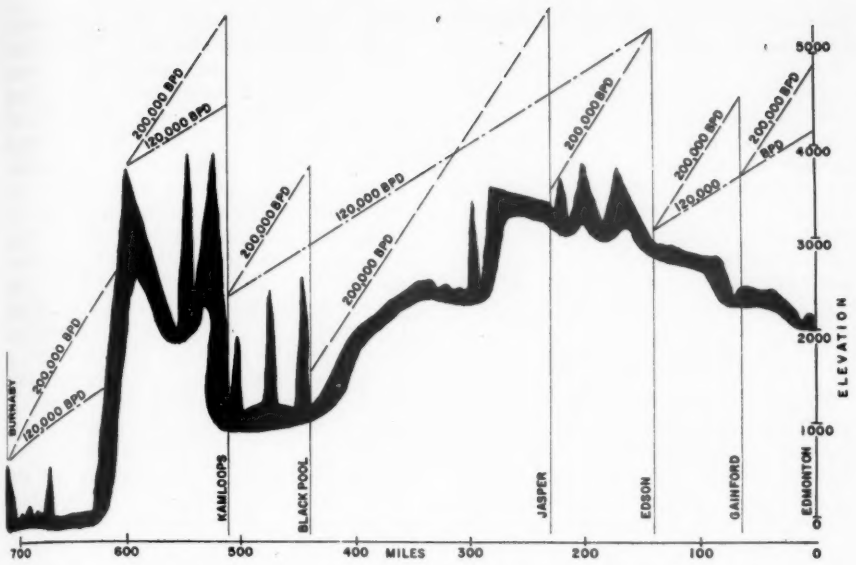
The line next was bisected and recharged and repressured with the dye solution. By a further bisection, the leak was isolated in a 6-mile portion, but despite use of the dye, it did not appear. Finally the weather cleared and, with an M-Scope equipped with an improvised super-amplifier, the elusive leak was found. It was on the bottom of the pipe in sandy soil at the highest point in the 28-mile section where the internal pressure was lowest. The cause was an unobserved small hole in the pipe wall.

Initial Fill and Tariffs

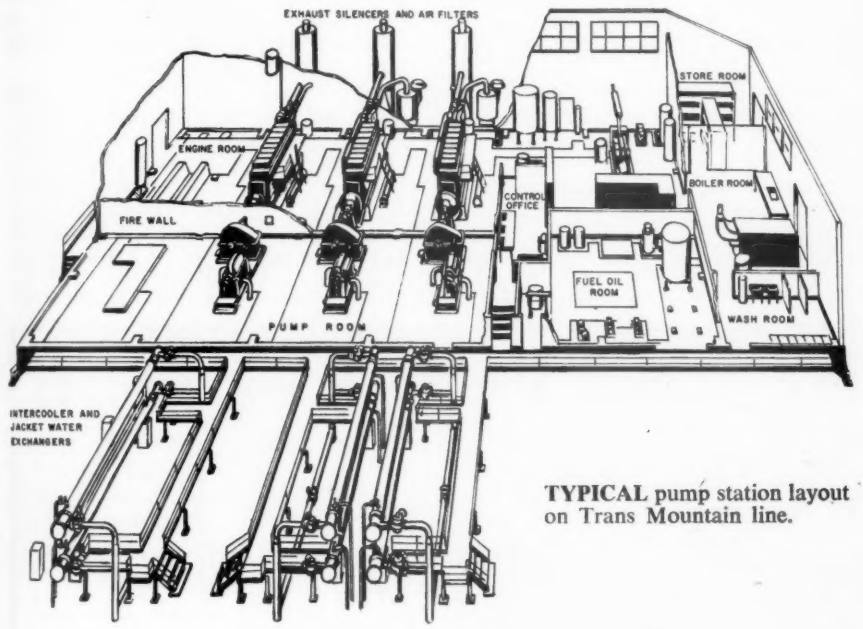
The volumetric capacity of the 718 pipe miles of 24-in. main line is almost exactly 2,000,000 bbl. The initial oil was pumped into the line to displace the water at a rate of about 75,000 bbl daily, with interim shutdowns as required to accommodate the line completion and pressure testing program still in progress ahead. Rubber plug-type "pigs" or scrapers were run ahead of the oil and between each batch interface. Pumping of the oil (through pressure-tested sections only) on such an intermittent schedule was started August 23, 1953, with its arrival in Burnaby scheduled about October 5.

Trans Mountain's tariff provisions follow common practice in the industry. They provide for reasonable effort by the company to deliver oils by types to the extent its facilities permit segregation. For continuous shippers the minimum tenders are 100,000 bbl in any 35-day period, with receipts and deliveries limited to 15,000 bbl minimum lots. "Occasional" or spot shipments of 50,000 bbl minimum will be accommodated providing facilities are available and the entire shipments can be received and delivered in single lots.

The tariff rate published initially for the trunk line movement from Edmonton to Burnaby is 45 cents per bbl de-



PROFILE and hydraulic gradient of 718-mile line, with figures given for both 120,000 and 200,000 bbl per day capacities.



TYPICAL pump station layout on Trans Mountain line.

livered. The normal evaporation and loss allowance of one per cent is called for by the tariff. The company undertakes to load tankers at its Westridge marine loading dock for 2½ cents per bbl. The refiner shipping via the projected spur line into Ferndale, Washington, has been quoted a through rate from Edmonton of 2 cents per bbl above the Burnaby rate.

Dispatching Problems

Trans Mountain's terminal arrangements and tariff anticipate the movement of crude oils in batches segregated by type. The safeguarding of crude segregation will be a constant duty of the Trans Mountain dispatchers. Such segregation will be undertaken to the extent possible with available terminal tankage and uncertain line hydraulics on precipitous western slopes. The first scheduled shipments are of three types of crude designated as "Redwater," "Leduc" and "Light Mix," the latter coming from Joseph Lake, Armena, and Camrose fields.

The Edmonton terminal is fed by the same five feeder lines that serve Interprovincial's trunk line to Superior as well as three local refineries. Thus, a co-ordination of the scheduling and dispatching of all feeder pipe line deliveries into the Edmonton area is essential for good operation, besides achieving more-efficient utilization of the tankage of all recipients concerned.

Trans Mountain's own trunk line dispatching is handled on an around-the-clock basis from the Vancouver head office. Working shifts, the dispatchers normally communicate with terminals, stations and other points over the telephone circuit. The teletype is used to transmit extended dispatching orders, and to gather the 7 a.m. daily reports. It is available also should the telephone circuit fail, as are also the nine fixed radio stations along the route which operate so effectively in the "medium frequency" band.

Trans Mountain dispatchers are responsible to "call signals" for the general results desired, and to issue specific orders for main valve changes, etcetera; but detailed handling of stations to accomplish results are left to local responsibilities.

Because of the waxy nature of the Alberta crude oils, and the tendency of such wax to congeal and adhere to the pipe wall — especially during winter temperatures — it is necessary to run "pigs" or scrapers through the line at frequencies of about 5 to 7 days. These are placed in and taken from the line at "scraper traps" located 75 to 110 miles apart along the line. The scheduling of these scrapers, which are handled in the field by the station operating and line maintenance crews, is another responsibility of the dispatchers. It is, in fact, an important one because main line valves must be opened and closed in careful sequence and timing to avoid any unexpected or disastrous line shut-off.

Mobile Equipment

A most difficult problem in the field is transportation of personnel and heavy work equipment. Western Canada's main road systems do not cross the Rockies and the Cascade Range via the Trans Mountain route, although — along the pipe line — improved roads are accessible for a total of 370 miles. About 165 miles of line are near seasonably fair roads; about 75 miles are in sections where roads are impassable in winter, and about 110 miles have practically no roads. Thirty to 50 ft of snow falls annually in these two sections, and all of the poor roads or lack of roads are in the mountains. Even travel over the 235 miles of good road from Edmonton to Jasper is precarious during much of the winter, and truck travel is restricted during the spring thawing periods.

About 600 miles of the route are generally paralleled by the Canadian National Railway. Passenger service, however, is practically on a once-daily basis because the two excellent passenger trains daily in each direction run about one-half hour apart. The Canadian Pacific Railway operates over the Coquihalla Pass route, but this line is frequently immobilized during two or three months of winter by heavy snowfall. Air line service in the West is excellent, but is available to Trans Mountain only between Vancouver and Edmonton and between Vancouver and Kamloops.

Because of the foregoing conditions, all maintenance crews are equipped with a variety of four-wheel drive vehicles consisting of jeeps, power-wagons, and 4-wheel drive trucks. Experience on snow-covered roads will be gained this coming winter by trial operation of snowmobiles, snow-cats and muskeg crawlers.

Certain crews are equipped with track-type tractors and ½-yd backhoes. Over passable roads these are transported on heavy-duty trailers towed by the trucks. For movement

into otherwise inaccessible areas, three railway units — each consisting of a heavy-duty flat-car and a combination sleeping-and-boarding car — have been obtained. Co-operation of both the Canadian National and Canadian Pacific railways in the emergency movement of this equipment has been assured.

Personnel

At the outset, the Trans Mountain organization comprised only its Board of Directors and their construction committee. They engaged the services of Canadian Bechtel Limited to design and engineer the line, and to act as agent for its construction.

About mid-1952, the directors laid plans to employ and train a permanent operating organization of Canadian or British Commonwealth personnel. It was recognized that Trans Mountain was a non-affiliated corporation, and that a self-sufficient management and operating staff would be required. Studies indicated the need for an organization of approximately the form shown in a chart accompanying this article.

The several staff departments will headquarter in the Vancouver head office. Line supervision of field operations will be through the general superintendent at Kamloops and the district superintendents at Edmonton and Vancouver. Terminal and station operating groups are as indicated in the chart, as are also the several special maintenance personnel.

Line and right-of-way maintenance presents the most difficult problem because of the long sections of rugged terrain along the route, the bitter winter weather encountered, and the very limited rapid transportation facilities available. Thus, it was decided to establish six pipe line maintenance headquarters along the route at 90 to 140 mile intervals depending on availability of passable winter roads.

Staff and Training

With the recent building of several new Canadian crude oil and products pipe lines, the hiring by Trans Mountain of a staff of Canadians experienced in pipe line operations was not possible. Thus it was necessary to employ qualified personnel from other walks of life and give them the necessary training. To accomplish this, a team of five experienced American pipeliners was engaged on a temporary basis. More than 2000 applications were reviewed in hiring the first 150 new employees.

Through subsequent co-operation of 14 American pipe line companies, several of which had no affiliated interest in the Trans Mountain project, a group of the most senior Canadians was permitted to visit and generally study the operations of those companies in Illinois, Missouri, Louisiana, Texas, Utah, and California. Later, groups of operating and maintenance supervisors, station operators and dispatchers were given detailed training at stations, tank farms, and offices of the Shell, Richfield, and Salt Lake pipe line systems under actual operating conditions. Some of these groups were given instruction by the manufacturers in the Nordberg engine plant at St. Louis, Missouri, and the Bingham pump plant at Portland, Oregon. Special help was given also by Interprovincial Pipe Line Company in Alberta, and by Portland Pipe Line Company in Maine.

During July and August, practically all Canadian employees, including office workers, were given a two-weeks' course in Trans Mountain's new Procedures Manual. This is a modification of a similar manual prepared by Shell Pipe Line. Actual participation in some of the station, line, communication, and housing and office building construction work, and in the line pressure-testing program, as well as reviewing all equipment layouts from an engineering aspect, served further to train numbers of the personnel for the difficult operating job ahead.

By August 1953, the new head office staff, the operating and maintenance supervisors, and station and terminal operating personnel had received most of their outside training, and were preparing for actual operations. Thus the directors' policy to engage only Canadian or British Com-

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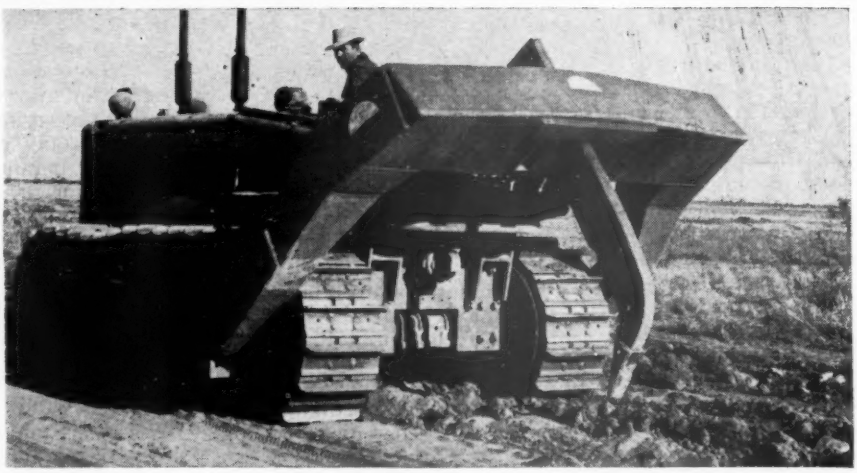

Positive Control! Plows Straight as Tractor will Walk!

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monwealth personnel in the permanent staff was implemented.

A study of the available housing along the route showed that, with the exception of the Edmonton and Vancouver areas, suitable homes could not be found for the company's future employees adjacent to pump station and pipe line maintenance headquarters. Thus the directors approved the construction of houses at all locations except Edmonton and Vancouver, and a contract for 101 houses was let. Ninety of these houses in nine groups will be finished late in 1953. The largest group, on Crescent Heights in Kamloops, contains 18 houses.

The houses are of two types. Both types are 1½-story, with full basement and attached garage. Despite the general standardization of style, wide variety in the colors of the asbestos shingle siding and roofing, curved streets and site terracing will give the house groups a pleasing appearance. Fencing, landscaping, etc., have been included in the group layouts.

The houses will be equipped with furnaces, hot water heaters, stoves and refrigerators. Cooking and heating is with propane gas, which has been contracted for at all sites. Because of the absence of public utility or station-generated electric supplies at two of the more-remote locations, Blue River and Brookmere, 40-kw engine-driven generating plants are being built. General contractor for the houses is Bennett and White Construction Limited.

Head Office Building

The erection of a head office building for Trans Mountain at 400 East Broadway, Vancouver, British Columbia, was commenced in August, 1953. The building is L-shaped in plan, and initially will be one story in height, although provision for later erection of a second story is made. The facade will be of Roman brick and aluminum, which will be set off by landscaping along the principal frontages.

The main floor, which covers 10,400 sq ft, will contain special layouts for executive suite, conference room, drafting room, accounting rooms and dispatching room. All offices have unobstructed outside windows, and most are 14 ft deep to a corridor — their widths differing according to their purposes. The basement, of 4000 sq ft, will contain rooms for storage, utilities and services, and an employees' lunch room.

The use of fixed corridor walls with movable transverse partitions of Philipine mahogany permits modification of layout to fit changing office needs. The floors in corridors and general areas will be of vinylite tile. Those in entrance and lobby will be of terrazzo. Executive offices will be carpeted. Ceilings will be of acoustic tile, set flush with the fluorescent lighting fixtures. Cold weather heating will be by warm air distributed through ducts in corridor ceilings and returned through wall registers and under-floor ducts. The same system will serve for fresh or cooled air circulation in warm weather.

The site is near the junction of the Trans Canada, Lougheed, and Douglas Highways, with convenient access from Burnaby and inland points along the main and spur pipe lines. The site will contain a paved parking lot for office and field employees of about 12,000 sq ft enclosed by a chainlink fence. General contractor for the building is Jarvis Construction Company, Ltd.

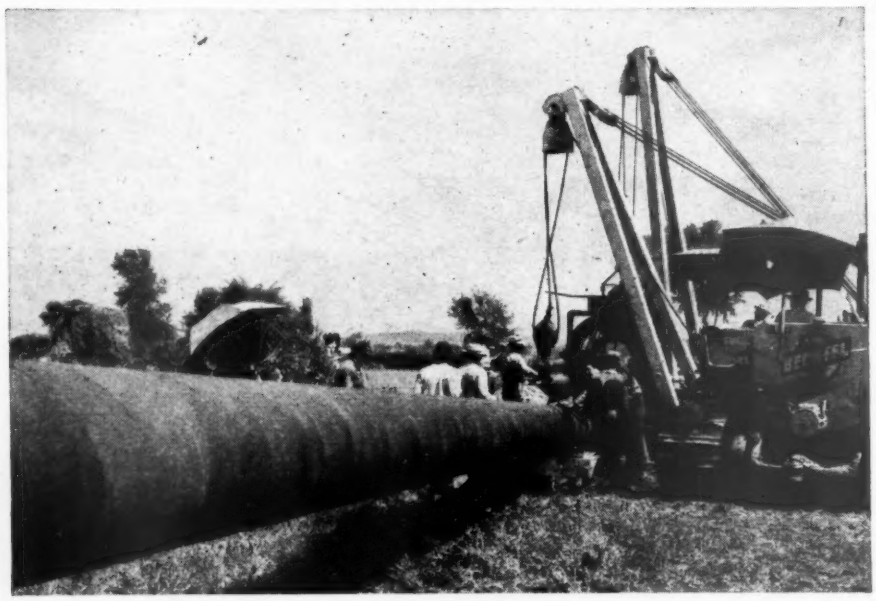
Occupancy of the office building is planned for mid-December, 1953. The Trans Mountain head office and Pacific district organizations are operating meanwhile from temporary headquarters at 1070 Hornby Street also in Vancouver. The company's office at 465 Victoria Street, Kamloops, is headquarters of the general superintendent and the special maintenance personnel. The Edmonton office at 10128 103rd Street is headquarters for the Prairie district.

* * *

☆ ☆ ☆

Rehearing on Gas Export Denied Trans-Canada

The Federal Power Commission has denied an application by Trans-Canada Pipe Lines, Ltd., for rehearing of the FPC's opinion No. 261 and order issued September 1, authorizing Tennessee Gas Transmission Company and Niagara Gas Transmission, Ltd., of Toronto, Canada, to export natural gas from the United States for ultimate consumption in the Toronto, Ontario, market area.



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ODESSA, TEXAS
June 22, 1953

To Whom It May Concern:

WE RELEASE THE FOLLOWING REPORT:

In the latter part of 1948, our company planned to expand our facilities to pick up flared gas in the South Cowden Field near Odessa, Texas. Because of a steel pipe shortage at that time, new pipe could not be obtained and the company purchased approximately 126,000 feet of light-weight 3rd class invasion pipe, sizes 4", 6", 8", 10" and 12" that had been used in water systems. Tubercular formations had substantially reduced the inside diameter of all the pipe. After cleaning and close inspection, it was found to be in critical condition. It was badly pitted and full of small pinholes. An attempt was made to make repairs by welding, but the pipe was in such poor condition that the repair program was abandoned.

At that time, a new company with a new process of cleaning and plastic-coating pipelines (in place) was proving their method of internal pipeline protection in the field. After investigation of this new company, known as Curtis-Tomlinson Co., Ltd., now PIPELIFE, INC., of Odessa, Texas, Odessa Natural Gasoline Company entered into a contract with Curtis-Tomlinson Co., Ltd., to lay, clean, and plastic-coat internally (in place) the entire gathering system. After the plastic coating job was complete, the lines were tested with 120 p.s.i. air pressure and no leaks were found.

These lines have been in constant service since 1949, and no failures have occurred. All lines have given over four years of satisfactory, trouble-free service. Uncoated (new) pipe carrying the sour gas from this same field will begin to fail from internal corrosion in three years or less.

ODESSA NATURAL GASOLINE CO.

W. D. Noel

WDN/jg

W. D. Noel, President

Sour gas gathering system in service over FOUR years without maintenance

Here is one of many instances of documented proof that the Pipelife method pays for itself.

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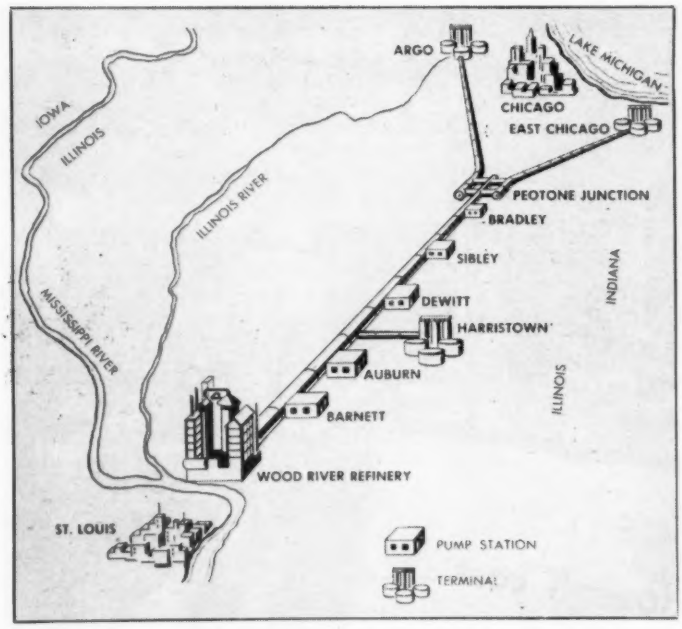
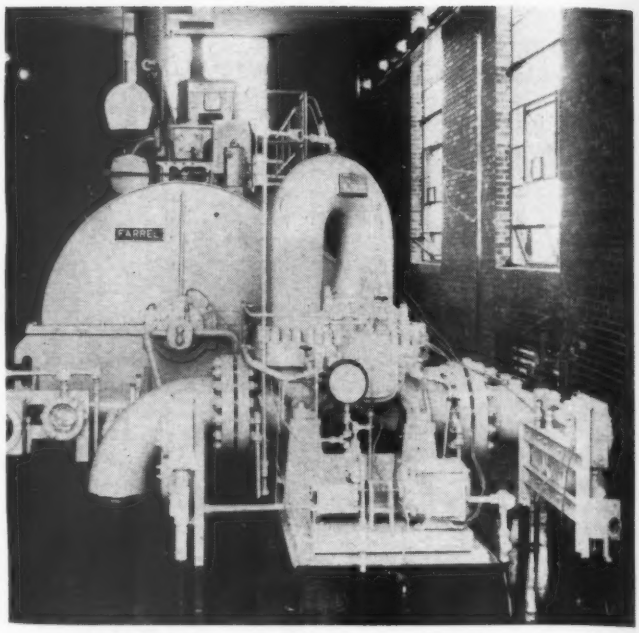


GRAPHIC illustration of Shell Oil Company's new 14-in., 279-mile Wood River carrier. New 1210-hp engines are installed at Auburn and Sibley, Illinois, stations.



NEW ADDITION to Shell's Auburn, Illinois station houses a 1210 hp pumping engine, a two stage centrifugal pump, and a speed increaser.

Wood River Line Features Modern Design

Shell's 279-mile, 14-in. products carrier includes many new concepts of pipe line design and operation

INCORPORATING the most modern concepts of products pipe line design, Shell Oil Company's new 14-in. Wood River carrier has been highly efficient in its first nine months of operation.

The new line, which runs 279 miles between the Wood River refinery and terminals at Argo, Illinois, and East Chicago, Indiana, replaced an old 8-in. line which transported 34,000 bbl per day. The new line has an initial daily throughput capacity of 85,000 bbl and an ultimate capacity of 120,000 bbl when the full complement of pumping facilities is installed. Power on the line is now provided by two 1210-hp supercharged diesel engines[1] in stations at Auburn and Sibley, Illinois, together with electric motor drives at the Wood River station and the engine installations that powered the original system.

Construction of the new 14-in. carrier, which cost more than $10,000,000, began in May 1952. It was laid parallel to the older 8-in. line with products, at times, running through segments of both 8 and 14-in. pipe to maintain continuous throughput. As each section was completed, the 8-in. pipe was removed and salvaged.

The original line was laid in 1927 for transporting crude to Shell's former East Chicago refinery. With the expansion of Shell's Wood River refinery in 1940, the line was converted to products transportation. East Chicago, with its storage capacity of 2,500,000 bbl, now serves as a product terminal.

Prime Movers

The new prime movers in the Auburn and Sibley stations are four-cycle, supercharged diesel engines with eight cylinders of 13-in. bore and 16½-in. stroke, rated 1210 hp at 460 rpm. Each engine drives a two-stage, horizontal split case, centrifugal pipe line pump[2] through a speed increaser[3] with a ratio of 1:8.205. The pumps have a rated capacity of 4160 bbl per hour. Each is equipped with double mechanical seals with separate seal oil circulating pump.

The engine at Auburn, as well as at Sibley, is set up in series with an 810 hp diesel engine. These 810 hp units, in addition to similar engines in stations at Barnett, DeWitt and Bradley, Illinois, were installed in 1947. Line pressure is established at 900 psi and varies with product and temperature. Currently, 22 different products are being carried through the line with gasolines and fuel oils the principal products.

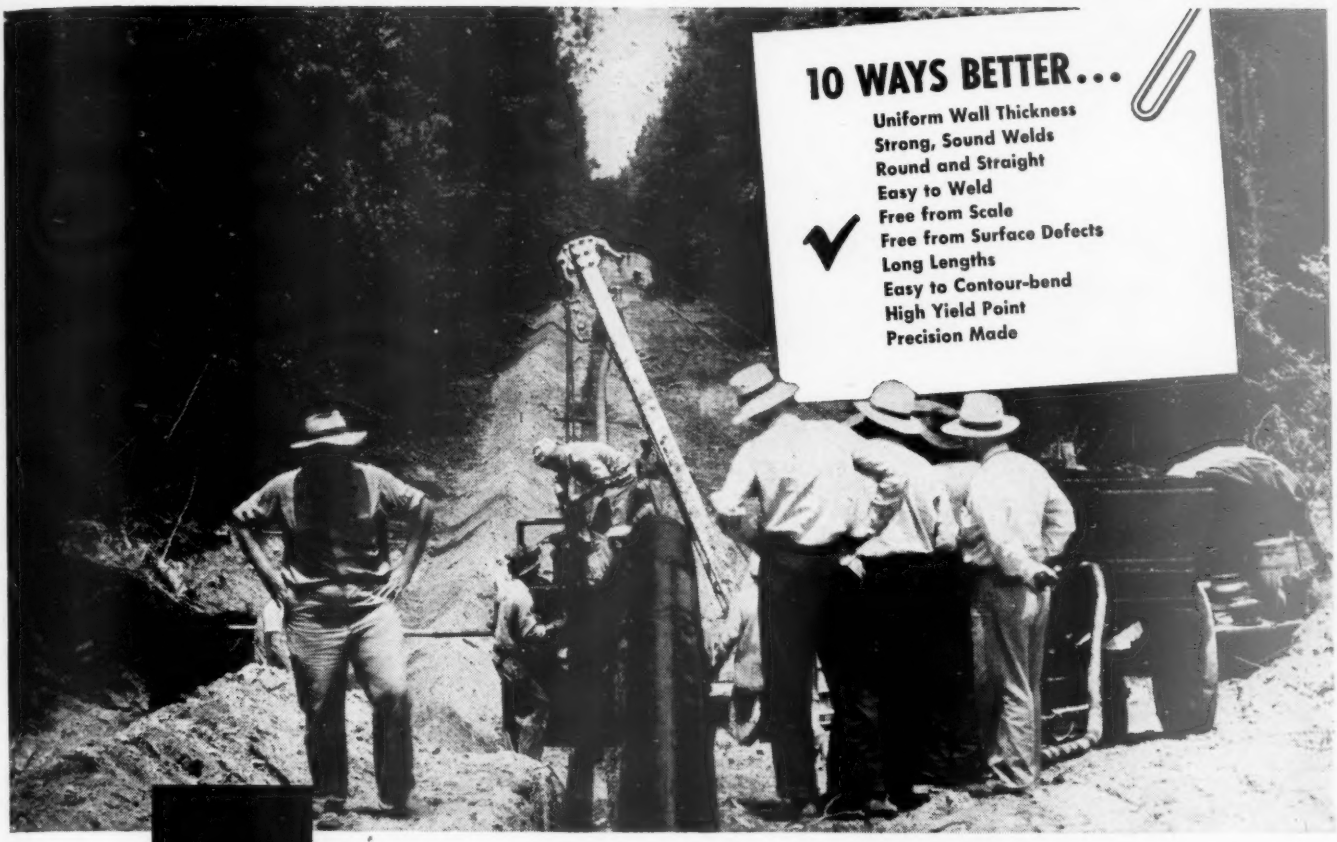
The new Shell carrier is hydraulically balanced to maintain a constant pressure differential and assure maximum throughput. All-welded seamless steel pipe was used throughout the line. Wall thickness varies from .312 to .375-in. with the heavier pipe laid principally in the metropolitan areas.

Operations

One of the many unique features of this new products line and other lines operated by Shell is the system whereby the products are dispatched via a teletype communications network from Shell's New York office. Teletypes at the main office, pumping sta-

[1]Nordberg.

[2]Byron Jackson.
[3]Farrel Birmingham.



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REPUBLIC ELECTRIC WELD LINE PIPE

Clean *inside* surfaces reduce the likelihood of clogged valves and regulators when a Republic Electric Weld Pipe Line is put into service.

Clean *outside* surfaces help speed coating and wrapping of the line, with fewest holidays.

Other advantages of Republic Electric Weld Line Pipe include rapid, plumb alignment of the uniformly round ends for welding; uniform wall thickness to assure uniform strength; high ductility for smooth, rapid field bending.

More than 67,000 miles of Republic Electric Weld Line Pipe have been laid these past 24 years on all types of transmission, gathering, distribution, and product lines . . . proof of dependability at low laying cost and maintenance cost.

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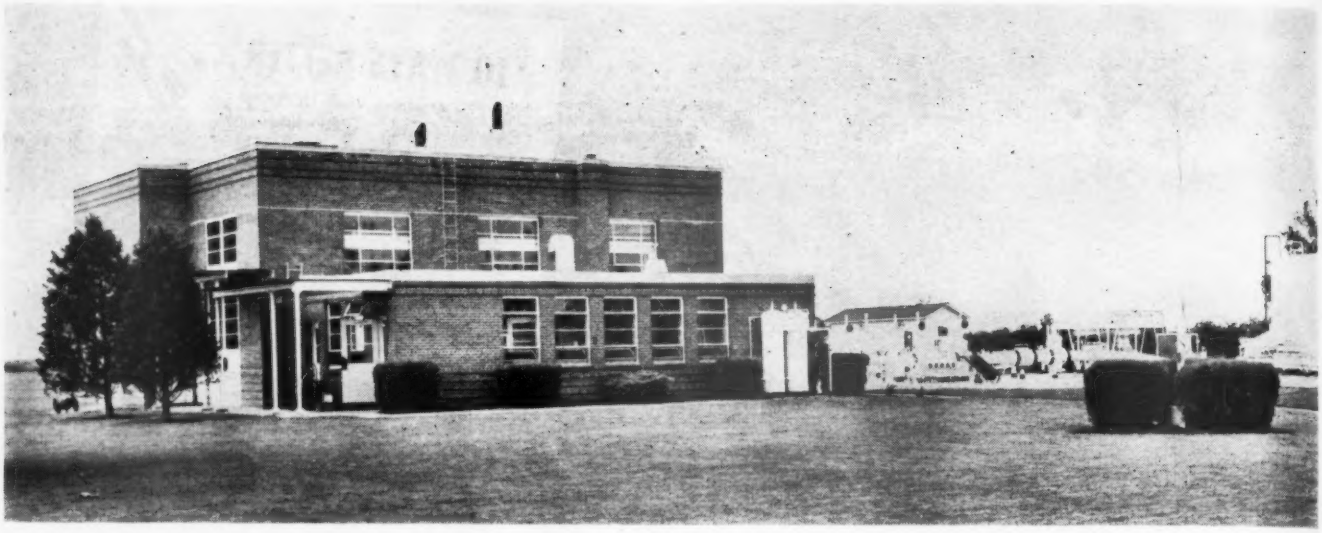
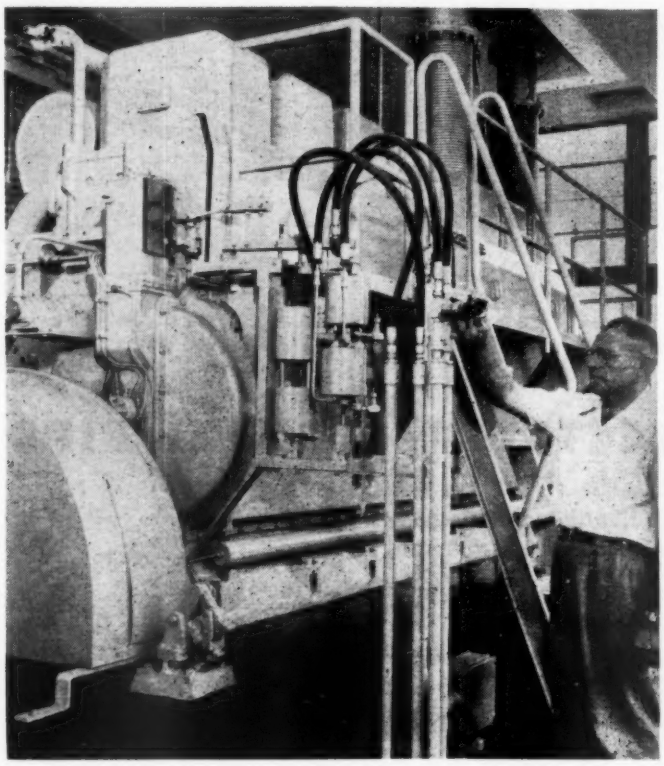


MODERN, well kept exterior of Auburn station.



W. MELLENBERGER, chief operator of Shell Oil Company's Auburn, Illinois, station adjusts a valve on the automatic starting system for the 1210 hp supercharged diesel.

CONTROL ROOM of the Auburn station with station chief Mellenberger at teletype. W. J. Wagert, and G. D. Harden, division engineer, and chief chemist respectively of North Line, are at panel.

tions and terminal points are in continuous operation with line rates and products co-ordinated to predetermined schedules.

Another salient point of operation is the system developed for automatic starting and operation of the pumping units. This system utilizes the usual governor as an overspeed device only, with the primary control of the engine functioning through direct hydraulic cylinders that position the fuel racks in response to changes in station suction and discharge conditions. Air actuated cylinders provide the start and stop sequence.

On a push button or automatic start, following the opening of the main pump valves and the establishment of pump seal oil and engine oil circulation, the start cylinder receives air through a solenoid valve, extending its piston to open the fuel rack wide at the same moment as starting air is admitted to the engine. When the engine fires and differential pressure across the main pump increases, the solenoid valve to the idle cylinder opens, admitting air to retract the fuel rack to idle position. After a delay through an electric timer, the air is released at a controlled rate by means of a time tank, allowing transition of the engine from idle to control speed over a period of approximately five minutes. This multiple sequence insures time to warm up a cold engine and the gradual application of load.

Special Features

In these and several other aspects, the new line is a pipe line of the future. For the first time refinery base stocks are blended into finished products as they enter the line. This is accomplished by pumping gasoline component stocks through separate lines into a special "component blending" unit, which in turn feeds the finished products directly into the line with significant savings in time and tankage. * *

HOVERING A few feet off ground is new Bell Helicopter recently leased by H. C. Price Company. Helicopter holds a pilot and two passengers. Empty weight is only 1400 lb, but it will pick up a useful load of 950 lb. It cruises at 80 miles an hour and will climb 970 ft per minute to a maximum of 13,000 ft.

PATROL PILOT for Service Line Company's Oklahoma division swoops low over Pauls Valley station during his weekly patrol. Five patrol planes cover the company's 12,150-mile pipe line system that operates in 11 states. Patrol system observed its seventh anniversary.

Petitions Ask Approval On Pipe Line Changes

Petitions have been filed with the FPC for changes in natural gas pipe line projects previously approved for construction in the Southwest, involving El Paso Natural Gas Company, of El Paso, Texas, Permian Basin Pipeline Company, of Chicago, Illinois, and Northern Natural Gas Company, of Omaha, Nebraska.

One of the petitions, filed by El Paso, requests the FPC to permit changes under which Permian will transport natural gas for El Paso from the Spraberry area in Texas, and also proposes the redesign and rearrangement of pipe line facilities in the Spraberry area. Total net savings in facilities to be constructed by El Paso, by the proposed deletions, would be $5,884,910.

The other petition, filed jointly by El Paso, Permian and Northern, seeks authority for certain operational changes in the arrangement under which gas is delivered by Permian to Northern through El Paso's facilities.

The petition filed by El Paso involves an expansion program authorized by the Commission last June under which the company will increase the daily capacity of its pipe line system by about 400,000,000 cu ft per day. El Paso said that it has entered into an agreement with Permian under which the latter company will transport up to 225,000,000 cu ft per day from the Spraberry area to El Paso's proposed Plains compressor station in Yoakum County, Texas. This plan would avoid the necessity for Permian and El Paso building duplicate pipe lines from and to the same areas.

In connection with the second part of its request, for changes in facilities in the Spraberry area, El Paso said that the redesign and rearrangement would provide greater flexibility of operations, result in lower construction costs and lower costs of operation and maintenance.

The other petition, filed jointly by the three companies, relates to certificates issued by the Commission last May 1 authorizing the construction of pipe line facilities designed to make additional natural gas available to Northern.

As authorized, Permian is to deliver gas to El Paso at Wasson, Texas, with El Paso delivering an equivalent quantity of gas to Northern at Dumas, Texas, for the account of Permian. Under the operational change proposed in the petition, Permian would deliver the gas to Northern at Wasson, with Northern immediately delivering the gas to El Paso at this point. El Paso would then transport gas for the account of Northern, rather than Permian, and would redeliver equivalent volumes to Northern at Dumas.

The petition says that the changes would eliminate the measuring station now authorized for construction by Permian at Dumas, thus resolving operational and maintenance difficulties attending such widespread location of facilities as well as resulting in a saving in construction costs.

First 3-D Pipe Line Movie Filmed by Price Company

A 3-D construction movie—the first of its kind filmed for the pipe line industry—recently has been produced by the H. C. Price Company of Bartlesville, Oklahoma, and is now available for public showings.

The film is entitled "This Is Your Line." In approximately 12 minutes it covers construction work undertaken in 1953 on four major pipe line projects. Included are scenes of work done this year for Tennessee Gas Transmission Company, Texas Gas Transmission Corporation, Southern Natural Gas Company and Gulf Interstate Gas Company.

The film is in color and has a musical accompaniment. Technical requirements necessitate the use of a special projector lens and screen. Polaroid glasses must be worn by the audience. Requests for showings of this new movie should be directed to the H. C. Price Company, P. O. Box 1111, Bartlesville, Oklahoma.

Pasco-Spokane Products Pipe Line Completed

Completion of a $4,000,000 products pipe line between Pasco, Washington, and Spokane, Washington, has been anounced by Standard Oil Company of California.

The new line, constructed and operated by Salt Lake Pipe Line Company, is part of a $48,000,000 oil supply system developed by Standard and its subsidiaries to serve the Intermountain and Inland Empire areas. Included in the facilities are a $21,000,000 pipe line between Salt Lake City, Utah, and Pasco; a $16,000,000 refinery at Salt Lake, and a $7,000,000 crude pipe line supplying the refinery from Rangely field in Colorado.

New Technical Magazine

Worthington Corporation has announced the first issue of the technical publication, *Power and Fluids*. The new magazine will present articles and other editorial material.

The magazine will be issued quarterly and the editorial content will consist of useful and authoritative information for readers in the power and fluid handling fields. It will describe new product applications, processes and methods. Subjects covered will include installations, operation and maintenance of industrial apparatus and applications of particular interest because of specific problems involved.

Heavy Equipment Movie Out

The inside story on modern construction equipment, ranging from small blast-hole drills up to giant hydro-cranes, and including many types of machinery familiar to pipeliners, is now available from the Bucyrus-Erie Company publicity department at South Milwaukee, Wisconsin.

The film explains how modern equipment is conceived, designed, built, tested, applied in the field, and continually improved. Three-fourths of the film's footage is devoted to in-plant views, the remainder to on-the-job scenes of equipment actually at work.

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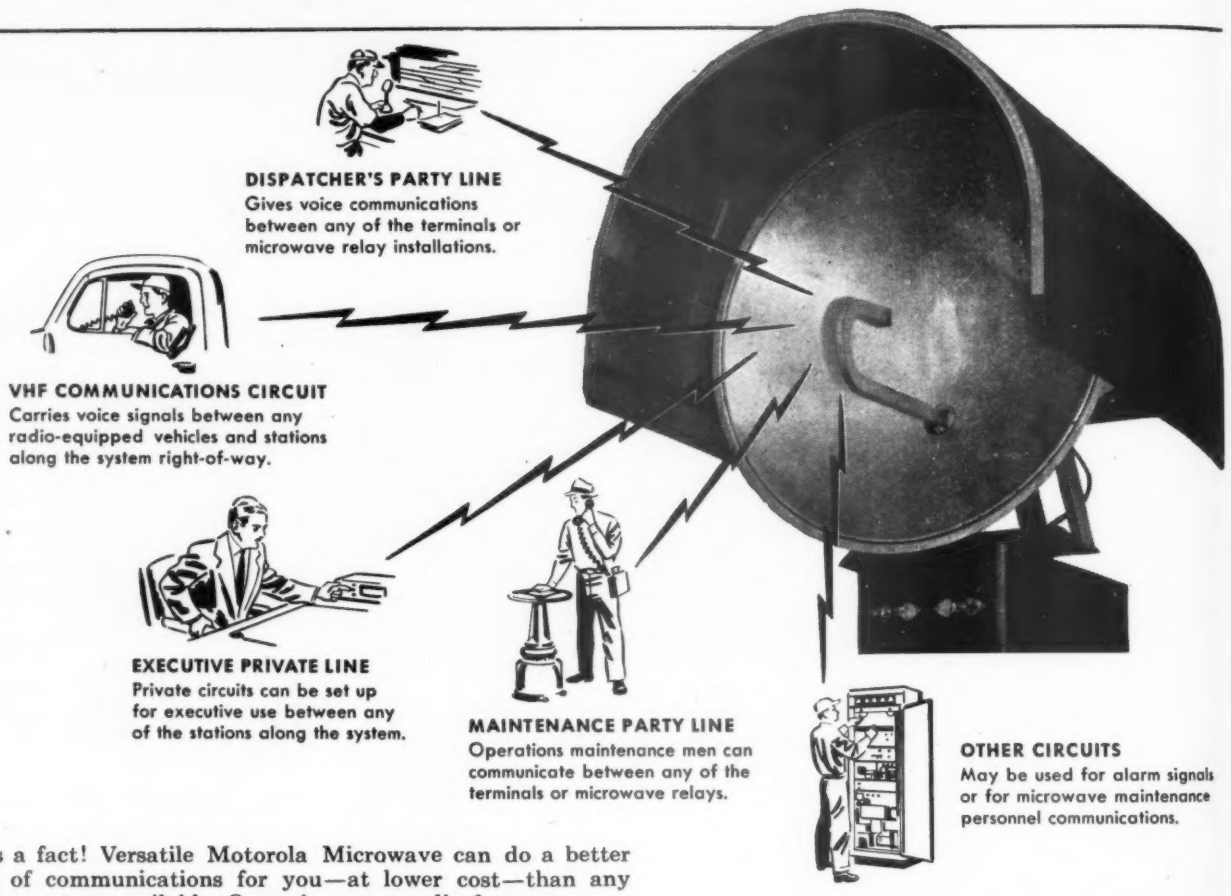
Dependable 24 hour a day communications cuts costs, saves man hours!



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Brazos River Electric Transmission Cooperative, Waco, Tex.
Illinois Power Co., Decatur, Ill.
Central Illinois Public Service Co., Springfield, Ill.
Pan American Pipeline Co., Houston, Tex.
Shell Pipeline Co., Houston, Tex.
Panhandle Eastern Pipeline Co., Kansas City, Kans.
Southern Counties Gas Co., Los Angeles, Calif.
La Fourche Telephone Co., Golden Meadow, La.
Mid-Valley Pipeline Co., Longview, Tex.
Greenwood Telephone Co., Greenwood, S. C.
*Bonneville Power Administration, Chehalis, Wash.
*Sinclair Pipeline Co., Independence, Kans.
Freeport Sulfur Co., New Orleans, La.
*West Coast Telephone Co., Everett, Washington
*Dayton Power & Light Co., Dayton, O.
Southern California Edison Co., Los Angeles, Calif.
*Middle South Utilities, Pine Bluff, Ark.

The trend is to MORE and MORE MOTOROLA MICROWAVE!

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Abstracts of Papers Presented at NACE South Central Regional Meeting, Tulsa

Cathodic Protection of Bare Pipe Lines in High Resistance Soil: by R. C. Martin, Plantation Pipe Line Company, Atlanta, Georgia. A brief description given of Plantation's entire system, comprised of 4, 8, 10, 12, 14, and 18-in. pipe totaling 2050 miles. Most of the pipe under 14-in. (about 900 miles) is bare. Leak experience to date is discussed. Most of the paper is devoted to experience on 4-in. lateral line in 20,000 to 70,000 ohm per cc of soil, where approximately 75 per cent of the leaks have occurred. Survey methods, magnesium anode, and rectifier installations are described.

Economics of Pipe Line Corrosion Mitigation: By L. G. Sharpe, Humble Pipe Line Company, Houston, Texas. The economics of controlling internal corrosion of sour crude oil pipe lines and storage tanks are discussed. Protective measures considered are internal linings, corrosion inhibitor treatments, non-metallic materials of construction, and non-ferrous materials of construction. The economics of coatings and cathodic protection for controlling external corrosion of pipe lines and tank bottoms are examined.

Cathodic Protection of Plant Yards with Distributed Anode Systems: By B. J. Whitley, Jr., corrosion engineer, Tennessee Gas Transmission Company, Houston, Texas. Observed corrosion and detailed pipe-to-soil voltage surveys, with interrupted current drain of plant yards revealed that the concentrated cathodic protection ground beds along the edge of the yard did not give good current distribution to protect the underground structures and piping in the center of the plants. The desired protection was obtained by distributing anodes through the yard at locations determined by the yard piping and the local current requirements. The procedure used to determine the design of the bed is discussed in the paper, and most of the design can be adapted to any specific yard. Installation of such a bed, adjusting the individual anode current output, intersystem bonding, rectifier maintenance, and the periodic pipe-to-soil voltage survey are discussed to enable a full understanding of the technique.

Internal Plastic Lining of Pipe In Place: By M. B. Grove, senior enginer, Pipe Line Research Section, Interstate Oil Pipe Line Company, Shreveport, Louisiana. A report of specific installations of plastic coating in place in new and old steel lines and in an aluminum line. Discussion of economics of this coating procedure is given and there is a brief summary of current techniques of surface preparation, coating applications, coating materials, and inspection control.

The Need for Proper Cooperation in the Design of Corrosion Protection: By Carl A. Erickson, Jr., The Peoples Natural Gas Company, Pittsburgh, Pennsylvania. A review of difficulties caused by poorly designed corrosion protection units and an appeal to corrosion engineers to cooperate with each other for their own welfare.

Experiences with Cathodic Protection on Montana Power and Light System: By Carl A. Davis, Montana Power and Light Company, Butte, Montana. A history of the Montana Power Company's experience in cathodic protection of gas distribution systems. Description of various types of ground beds, and cost curves showing relation of maintenance costs to cathodic protection are given. Examples of records are shown.

The Effects of Impurities on the Performance of Magnesium Anodes: By H. A. Robinson, Dow Chemical Company, Midland, Michigan. Paper is based on field data and extensive laboratory tests carried on at the Dow Chemical Company over the past several years. It deals with the effects of the alloying elements and minor impurities on the efficiency of Mg—6 per cent, Al—3 per cent zinc anodes and discusses these effects in relation to existing composition specifications. The alloying and impurity elements treated include aluminum, zinc, manganese, iron, nickel, copper, and beryllium.

Westcoast Financing Promised by Banker

Financing of the total $138,940,000 cost of the entire Westcoast Transmission Company, Inc., project to deliver natural gas from Alberta gas fields to the Pacific Northwest has been promised by a New York investment banker.

Edward T. Herndon, member of the Eastman, Dillon and Company firm, told an FPC hearing that his organization is prepared to finance the project if it is granted a license by the commission.

Financing of the pipe line, said Herndon, would be through $29,000,000 in 1 to 5½-year serial notes; $71,000,000 from 20-year, first mortgage bonds, and $24,440,000 from subordinated long-term debentures and common stock sold to the public.

'Better Blasting' Bulletin Now Available

First issue of a new quarterly technical bulletin, designed to assist mine and quarry operators, construction engineers, pipe line companies, lumbering firms and other users of industrial explosives, has been published by Atlas Powder Company.

The four-page illustrated bulletin, titled "Better Blasting," describes modern blasting techniques in practical, readable fashion. The last page is devoted to a chatty column called "Mac's Notes," written by David M. McFarland, manager of the technical division.

Copies will be mailed without charge on request to the Technical Division, Atlas Powder Company, Wilmington 99, Delaware.

Tidewater Lays Offshore Line in California

Tide Water Associated Oil Company has laid an 18-in. submarine pipe line off the Pacific Coast Shore at Ventura, California, to take crude from its Ventura Avenue field for off shore tanker loading.

The line goes out 4300 ft into the Pacific Ocean, the hose at the end to be raised for loading tankers and returned to the ocean bottom when loadings are completed.

The pipe line, when in operation, will be capable of loading at the rate of 9000 to 10,000 bbl per hour. The line has a weight of 200 lb per ft, a somastic protective coating to prevent corrosion, and an outer coating of gunite to give it weight to keep it submerged.

Supreme Court Rejects Mississippi Tax Case

The United States Supreme Court recently voted to reject a review of the Coleman v. Trunkline Gas Company case in which the Mississippi Supreme Court had held that the commerce clause bars imposition of the Mississippi privilege tax upon pipe line operators doing exclusively interstate business, measured by the mileage and size of the pipe within the state.

Another case of interest denied by the court was that of McClellan v. Montana-Dakota Utilities Company in which the Eighth Circuit Court of Appeals had ruled that a gas producer's 1950 Minnesota federal district court suit against a pipe line company for damages resulting from a pipe line company's refusal fror 1930 to 1940 to transport the producer's gas at reasonable rates is barred by Minnesota's six-year statute of limitations even though reasonable rates for service were not determined by FPC until 1949.

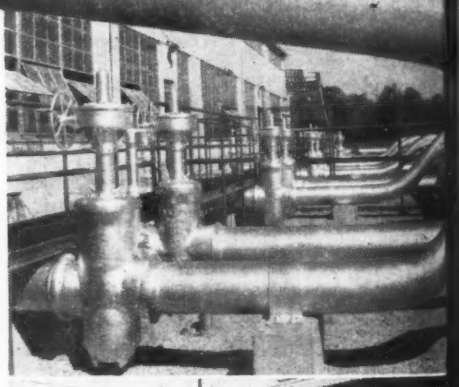
FPC Directive Sets Gas Delivery for Kansas-Colorado

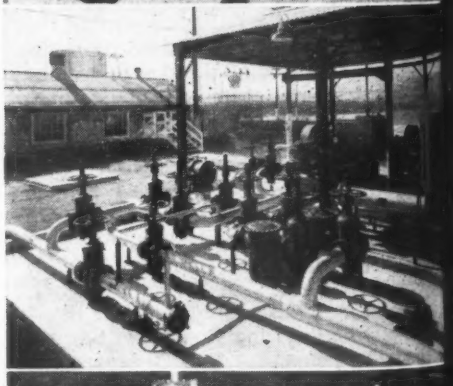
Chief presiding examiner Edward B. Marsh of the FPC has filed a decision, subject to review, directing Colorado Interstate Gas Company, of Colorado Springs, Colorado, to supply a maximum of 500,000,000 cu ft of natural gas per year to Kansas-Colorado Utilities, Inc., of Lamar, Colorado.

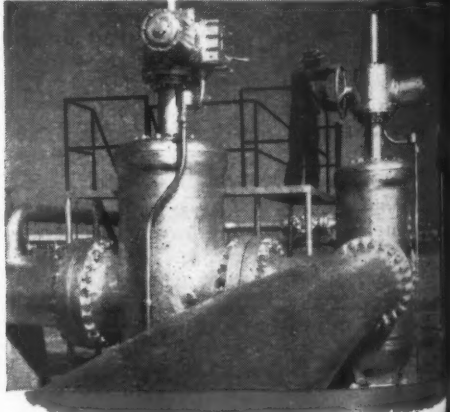
The gas is to be delivered at an existing connection between the two companies' systems at McClave, Colorado, during the months of May through October of each year. Kansas-Colorado filed its application last March asking the FPC to order the service, and Colorado Interstate did not oppose the request.

Kansas-Colorado had requested up to 5,000,000 cu ft daily, a total of 920,000,000 cu ft per year. Examiner Marsh, however, ruled that the evidence does not support a finding that it is necessary or desirable for Colorado Interstate to be directed to supply Kansas-Colorado with more than 500,000,000 cu ft a year.

NO MORE TURBULENCE . . .
NO MORE PRESSURE DROP
THROUGH HERE THAN HERE







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No Turbulence means a minimum of wear at the gate and seats — resulting in low or no maintenance costs involving these parts. **No pressure drop** means that the pump power is concentrated on the transmission of gas, oil and petroleum products, not wasted pushing it past obstructions.

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Pipe Line "Samaritan" Aid Water-Short City

Citizens in water-short El Dorado, Kansas, will be able to continue with business as usual thanks to Kaneb Pipe Line Company and the petroleum refiners and marketers in the state who have cooperated in the conversion of a products pipe line system to water service to relieve the critical water shortage that threatened a complete shut down of two major refineries and other industries in the city.

In addition to the close cooperation of the refiners and potential users of the products pipe line facilities, which include Anderson-Prichard Oil Corporation, Socony-Vacuum Oil Company, Inc., Skelly Oil Company, El Dorado Refining Company, Derby Oil Company, Vickers Petroleum Company and the National Cooperative Refinery Association, many physical problems had to be overcome.

To handle the large volume of water movement, Kaneb obtained and installed three portable pumping units from the Service Pipe Line Company that were shipped by special truck into Wichita. These units, operating through temporary lines and connections, will deliver 1,500,000 gal of water per day from Wichita into connecting lines in Augusta, thence to El Dorado and the city's distribution system. Kaneb Pipe Iine Company, owner of the products pipe line, has installed the temporary pumping equipment.

The severe drought in central and eastern Kansas has necessitated supplementing the water supply at El Dorado from outside sources to preclude a severe curtailment of water usage for sanitary and drinking purposes, as well as industrial uses. A shut down of the Skelly Oil Company and El Dorado Refining Company refineries, the two principal industries in El Dorado, would further aggrevate the crude oil production problem in central Kansas. These two refineries have a total refining capacity in excess of 60,000 bbl per day and crude suppliers would soon be forced to curtail or completely shut down crude production due to insufficient storage.

Through the cooperation of the Kaneb management, the City of El Dorado arranged for the purchase of water from the City of Wichita until overdue rain relieves the water shortage. This temporary supplemental water supply will permit the continued operation of the two refineries, an important factor in the welfare of the small oil community.

The Kaneb pipe line system, built by C-R-C Engineering Company, Houston, with its connecting carrier, the Augusta Pipe Line Company, was constructed primarily to give north, central and southern Kansas refineries a pipe line outlet into Nebraska. This includes refineries at Arkansas City, Augusta, El Dorado, Potwin, Wichita, and McPherson. While the emergency water system exists, a pipe line outlet for some of these refineries will be cut off and many temporary expedients are being used to handle the distribution of refined petroleum products from the various refineries.

Trunkline to Supply Gas To Illinois Company

The FPC has directed Trunkline Gas Company, of Houston, Texas, to supply a maximum of 2,000,000 cu ft of natural gas per day to Central Illinois Public Service Company, of Springfield, Illinois, at a connection to be established near the Neoga, Illinois, area.

The gas will help Central Illinois meet requirements in the Mattoon, Illinois, area, which includes Mattoon, Paris, Charleston, Ashmore, Kansas, Neoga, Sigel, and Effingham. Central Illinois is now able to receive up to 9,178,000 cu ft of gas daily from Panhandle Eastern Pipe Line Company for distribution in the Mattoon area.

Phillips Line Progressing

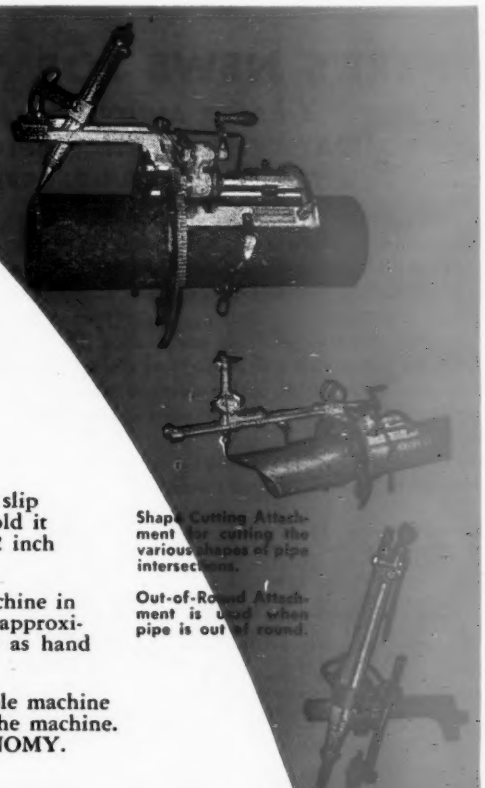
Phillips Pipe Line Company, wholly owned subsidiary of Phillips Petroleum Company, has completed construction on approximately 50 per cent of 44 miles of 10-in. loops on its products pipe line between Paola, Kansas, and East St. Louis, Illinois.

The addition of the loops will increase to approximately 76,500 bbl per day the capacity between these two points on the Phillips, Texas-East Chicago, Indiana products pipe line.

H&M

PIPE CUTTING AND BEVELING MACHINE

Cuts and Bevels Pipe FASTER, MORE ECONOMICALLY



Split horseshoe shaped gear permits machine to slip quickly over pipe. Fast operating snap chain fasteners hold it in place. A complete cut and bevel can be made in a 12 inch pipe in about two minutes.

You'll soon save several times the cost of the machine in labor, gas and transportation charges. H&M takes approximately one-half the labor and gas to make the cut as hand cutting and the work is all done in the field.

Bring this light (24 to 155 pounds) but durable machine to the pipe instead of moving the heavy pipe to the machine. Remember, H&M designs for SPEED and ECONOMY.

Shape Cutting Attachment for cutting the various shapes of pipe intersections.

Out-of-Round Attachment is used when pipe is out of round.

See for yourself. Let us arrange a demonstration.

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Pipe Lines Have Other Uses, Says Engineer

"The ultimate uses of pipe lines as a means of mass transportation give wide range to the imagination," George E. MacDonald, representative of the Great Neck, New York, engineering firm of Lockwood, Kessler and Bartlett, said recently in a paper presented at the annual meeting of the American Society of Civil Engineers in the Hotel Statler.

"As the petroleum industry expanded and developed, the need for economical transportation of its products to its markets, soon led to the advent of long range, 'big inch' pipe line as a means of transportation. Subsequent growth of the pipe line as an economical means of mass transportation has been a rapid modern day revolution.

"The office of Petroleum Administration for Defense estimates that about 163,000 miles of petroleum pipe lines were in operation within the U. S. as of January 1, 1953, and an additional 10,000 miles are expected to be placed in operation this year. The natural gas industries' expansion of operating transmission pipe lines has been no less rapid. The American Gas Association reports that from 1936 to 1951 the miles of transmission lines operating in the U. S. increased from 55,000 to 118,000 miles.

"Though the oil and gas industries are the undisputed giants of cross-country pipe lines, the ultimate uses of pipe lines as a means of mass transportation give wide range to the imagination.

"Successful tests have already been made by Pittsburgh Consolidation Coal Company on shipping coal by pipe line. Though still in a developmental stage, the piped coal is finely crushed, immersed in water and forced by pressure pumps through the pipe line. It was estimated that such a line from Cadiz, Ohio, to Lake Erie, a distance of over 100 miles, might conceivably deliver coal for $1.00 a ton less than rail fare, the current rail rate being about $2.75 a ton.

"The entire development of the pipe line industry was, of course, based on the fundamental fact that this was the most economical means of transporting great volumes of the product. Such economic transportation not only depends upon the operating costs of the system but also upon the initial construction costs. Each of these factors must be borne in mind when locating a pipe line and consequently the location survey may be considered the most important of the several types of surveys attendant to pipe line construction."

FPC Okays Abandonment Of Gas Deliveries

Examiner Emery J. Woodall of the FPC has filed a decision, subject to review, permitting Arkansas Louisiana Gas Company, of Shreveport, Louisiana, to abandon the natural gas service of about 12,500,000 cu ft per day to Mississippi River Fuel Corporation, of St. Louis, Missouri.

Arkansas Louisiana filed an application with the FPC last February proposing to abandon the service as of March 26. The Commission, however, suspended the notices of cancellation pending hearing and decision. Mississippi intervened in the proceeding in opposition to the proposed abandonment of service. A hearing was held June 17.

Examiner Woodall said that the load growth on Arkansas Louisiana's system and increased demands of large industrial customers have created a market for the 12,500,000 cu ft of gas now sold to Mississippi. He found that the record supports conclusions by the FPC staff and Arkansas Louisiana that the discontinuance of the service would result in economic benefits to the applicant.

Arkansas Louisiana would receive more return for the gas than Mississippi now pays, and the availability of this gas to Arkansas Louisiana would tend to postpone requirements for increasing the capacity of its transmission system.

The decision also points out that the 12,500,000 cu ft of natural gas represents only about 2.9 per cent of Mississippi's annual gas purchases, and that the increase in the average cost of gas to Mississippi would be very slight indeed. Mississippi had contended that the abandonment would mean a higher average cost of gas to it.

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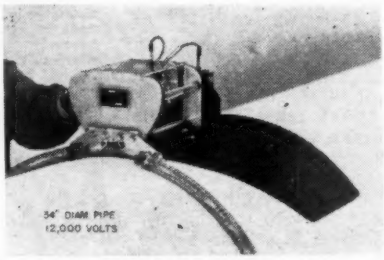
TINKER & RASOR ANNOUNCES A NEW HOLIDAY DETECTOR THAT OPERATES WITHOUT A GROUND WIRE!

• With the new Model H-2 Detector there's no trailing ground wire to cause trouble and delay . . . it has been replaced with a "double electrode" (Pats. Pend.) called a "saddle" which fits over the top of the pipe and travels along with the instrument. This combination provides constant inspection voltage on any pipe size under all operating conditions.

The newly designed electrode combination (U. S. Pat. No. 2,629,002) allows the helical spring electrode to be disengaged from operating side when passing over skids. Spring electrode revolves on sealed roller bearings. Provision is made for use of wand with full circle electrode or brush applications.

The Model H-2 Detector is available on a rental, rental-purchase or purchase basis. Write for complete details.

Includes instrument, 2 battery sets, battery charger, "saddle," helical spring electrode, and shipping case. Power input: 6 volt 22 amp.-hr. plastic storage battery. Average input current 3 to 3.3 amperes. Output Voltage: 12,000 to 14,000 on 12" to 30" diam. pipe. Pulse wave form of 7 to 8 micro second crest duration. Pulse rate: 35 to 40 c.p.s.



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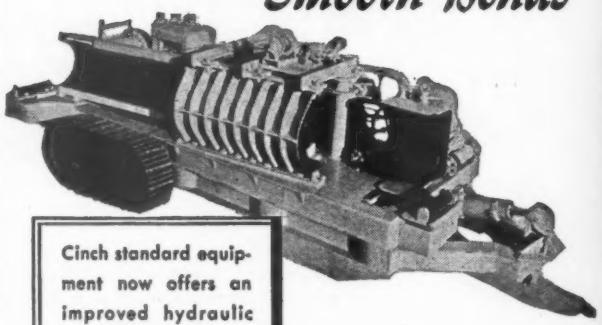

Cinch standard equipment now offers an improved hydraulic system and new wedge-type pin-up slide for greater durability and speed. If desired, even faster, easier maneuvering can be obtained with Athey tracks and hydraulic lift tongue.

Contractors swear by Cinch "Smooth Bend" Pipe Benders for dependability and uninterrupted service. Cinch Pipeline Equipment provides the most up-to-date equipment and expert maintenance.

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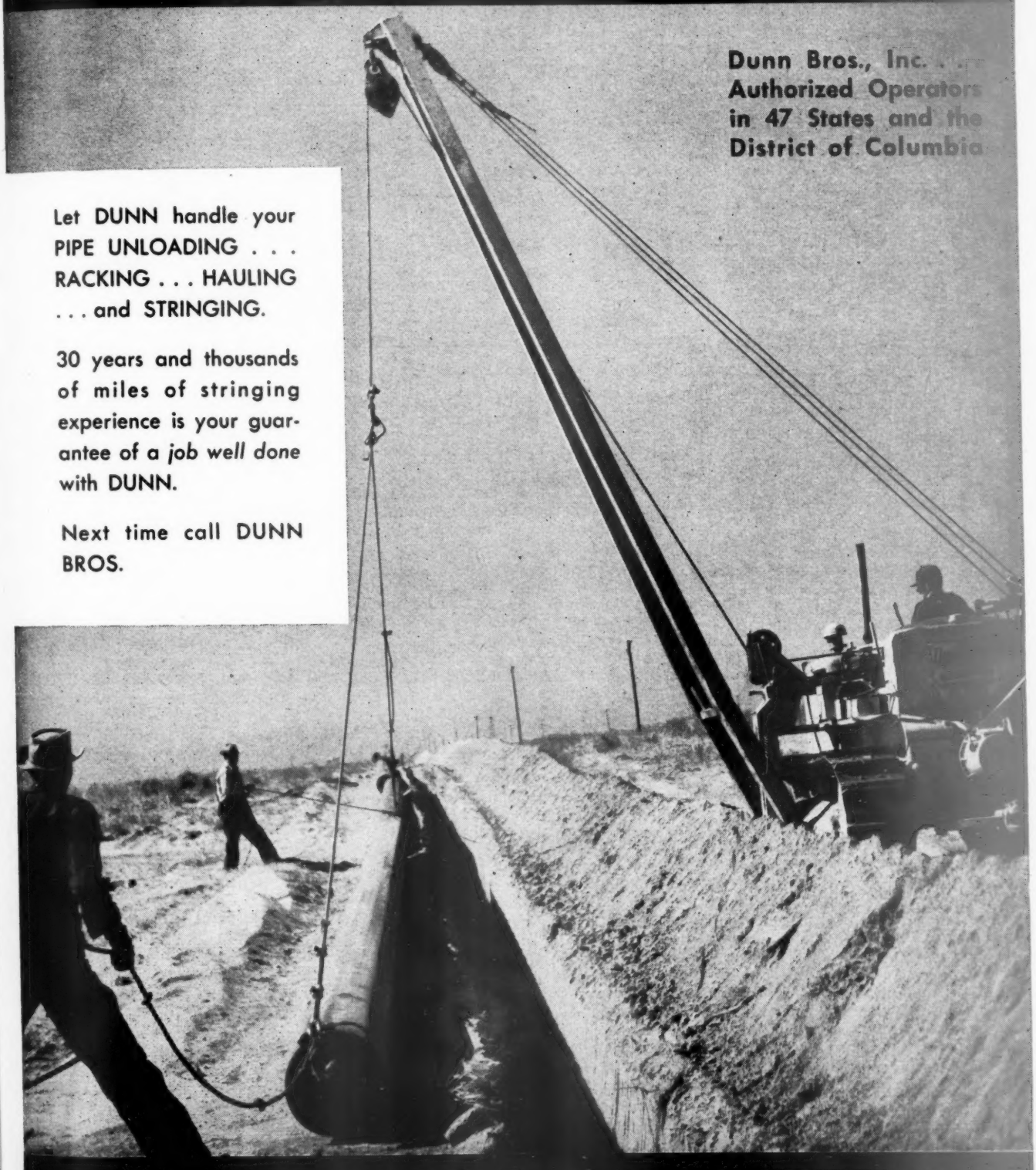

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PIPE LINE PROJECTS

Plans for 475-Mile Products Line Revealed by Sunray

A 475-mile products pipe line is to be constructed from Sunray Village (Duncan), Oklahoma, to a point on the Mississippi River, at West Memphis, Arkansas, directors of Sunray Oil Corporation have announced.

The proposed line will be operated by the recently organized Oklahoma-Mississippi River Products Line, Inc., and Sunray Oil Corporation will have a 50 per cent stock interest in this new pipe line transportation organization. The company's headquarters will be in Tulsa.

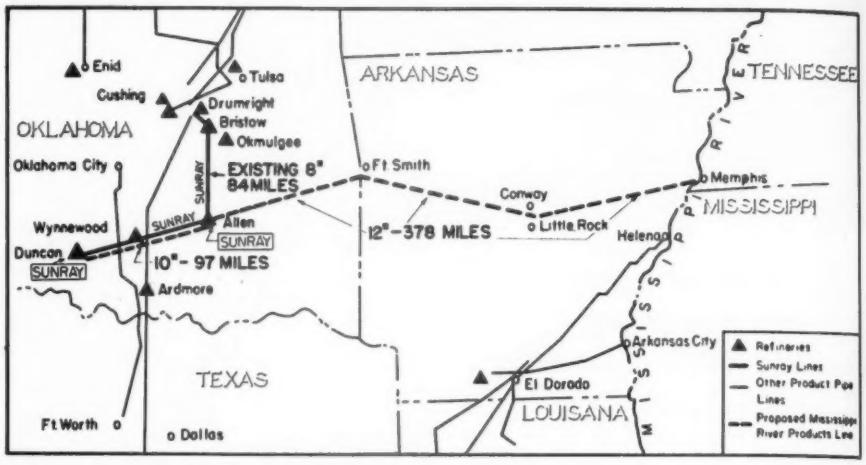
Independent estimates of the cost of the proposed pipe line system including pumping stations, storage facilities, and auxiliary installations will be approximately $25,000,000 for the initial proposed capacities.

In addition to Sunray Oil Corporation, which will put its products in the line from its refineries at Allen and Duncan, Oklahoma, facilities of the system will also be available to other refineries who have plants in the central and southern Oklahoma area. An 84-mile products line Sunray now operates between Allen and Drumright, Oklahoma, will also become part of the new system, and Drumright, Bristow, and Wynnewood will be other station exchange points.

The newly organized company will be headed by J. L. Shakely, Tulsa, who retired the first of this year as president of the Jones and Laughlin Supply Company. He will be president of the new company, and J. R. (Dick) Ellis, formerly manager of Sunray's pipe line department, will be vice president and general manager. Directors of the new company are in addition to Shakely and Ellis, Paul E. Taliaferro, H. O. Harder, and L. W. Bennett, officers of Sunray Oil Corporation; Lloyd Gilmour, senior partner in the investment firm of Eastman, Dillon and Company, and William G. McKnight, Jr., also of New York.

The new pipe line will have an initial products throughput of 35,000 bbl per day. The line will connect refineries in Oklahoma with a Mississippi River terminal from which products can be moved via barge to distribution points along the Mississippi and Ohio River waterways.

Transportation advantages of the new products pipe line are: (1) It will connect refineries in Oklahoma with the entire Mississippi River transportation system. (2) It has a greater flexibility than a pipe line between two inland points without water transportation. (3) The proposed tariff for the pipe line system, added to river barge transportation cost, should enable Sunray and other refiners in Oklahoma to ship petroleum products to any point on the Mississippi south of St. Louis and up the Ohio River at rates comparable to that of any existing product pipe line system, railroad tank car routing, or combination of these methods.



ROUTE of the proposed Mississippi River Products line.

Preliminary engineering for the proposed pipe line has been made by Ford, Bacon and Davis, Inc., with principal offices in New York, New York. The proposed system will provide pumping stations and facilities for receiving products at Drumright, Bristow, Duncan, Wynnewood, and Allen, Oklahoma. In addition, there will be pumping stations at points along route.

Yellowstone Construction Contracts Awarded

Construction of the 537-mile Yellowstone pipe line from Billings, Montana, to Spokane, Washington, has started, W. L. Kygar, president of Continental Pipe Line Company, a subsidiary of Continental Oil Company, has announced.

The contracts for the $20,500,000 products pipe line have been awarded to four contractors: Ross and Powers Construction Company, Billings, Montana; Associated Pipe Line Contractors, Houston, Texas; Eastern Pipeline Contractors, Dallas, Texas; and Engineers Limited Pipeline Company, Denver, Colorado.

The construction job is divided into six sections. Ross and Powers Construction Company will build the section from Billings to Bozeman, Montana; Associated Pipe Line Contractors, two sections, Bozeman to Helena and Helena to Clinton, Montana; Eastern Pipeline Contractors, two sections, Clinton to Perma, Montana, and Perma to Murray, Idaho; Engineers Limited Pipeline Company, Murray to Spokane, Washington.

Continental Pipe Line Company will direct construction of the line and will manage its operations through the staff of the newly formed Yellowstone Pipe Line Company. Continental Oil Company and Interstate Oil Pipe Line Company, an affiliate of Standard Oil Company (New Jersey), each own a 40 per cent interest in the Yellowstone line. Union Oil Company of California has a 14 per cent interest and the H. Carl Clack interests of Havre, Montana, and Spokane have a six per cent interest.

The 10-in. pipe line, scheduled for completion by September 1, 1954, will have an initial daily capacity of 30,000 bbl. It will transport petroleum products from refineries of Continental Oil Company and Carter Oil Company at Billings to consumers served by terminals at Bozeman, Helena, Missoula, and Spokane.

From Billings, the line will pass through or near Big Timber, Livingston, Bozeman, Three Forks, Helena, Garrison, Missoula, Ravalli and Thompson Falls, Montana, and Coeur d'Alene, Idaho, with its western terminus at Spokane. It will be laid over mile-high passes in the Rockies and will cross the Continental Divide just west of Helena at a height of 6200 ft. The most rugged construction work is expected to be encountered in the Coeur d'Alene National Forest in Idaho, which has virgin pine.

Gas Line Construction Okayed by Utah PSC

Utah's public service commission has approved a proposal by Mountain Fuel Supply Company to construct a new gas line in Utah County, Utah, to serve the communities of Salem and Payson. A certificate of convenience and necessity was issued by the commission and construction of the line is expected to begin shortly. Cost of the line is estimated at $600,000.

The Baldwin SR-4 Load Sensitive Unit Type T—20,000 Pounds. This newly designed cell, of monel metal construction, stands the rough treatment and corrosive atmospheres of the oil fields.

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THE SCHLUMBERGER PROBLEM:

The Schlumberger Well Surveying Corporation of Houston, Texas, required a means of observing cable tension during the tests they conduct in oil well drilling operations. Equipment was subject to extremely rough treatment and highly corrosive conditions.

THE BALDWIN SOLUTION:

Specially designed Baldwin SR-4 Tension Links, hung between the top sheave and the derrick cap, measure the tension in the cable supporting the survey equipment being used in the hole. Baldwin SR-4 devices operate on the principle of the famous SR-4 bonded wire strain gage.

SCHLUMBERGER BENEFITS:

1. When lowering equipment, suddenly decreased tension indicates a hang-up of equipment in the hole. Saves time—insures accurate records.
2. While in the hole, a continuous rough indication of cable and tool weight gives the operator an additional protective check for smoothness of his survey operation.
3. When pulling equipment up, suddenly increased tension indicates equipment caught in the hole, allowing correction to avoid cable breakage and losing or damaging expensive instruments. Saves time—saves money.
4. In field use, corrosive conditions and rough treatment are easily withstood by this Baldwin SR-4 unit. Avoids costly down time.

Baldwin SR-4 devices have uses unlimited in industry—measuring load, fluid pressure, or torque economically, speedily, and accurately. For the latest technical information please write to Department 3330, Baldwin-Lima-Hamilton Corporation, Philadelphia 42, Pa.

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PROJECTS

El Paso, Northern Building Gas Exchange Facilities

Certificates have been issued to Northern Natural Gas Company and Independent Natural Gas Company, both of Omaha, Nebraska, and El Paso Natural Gas Company, of El Paso, Texas, authorizing construction and operation of pipe line facilities which will make available up to 50,000,000 cu ft of additional natural gas per day to Northern.

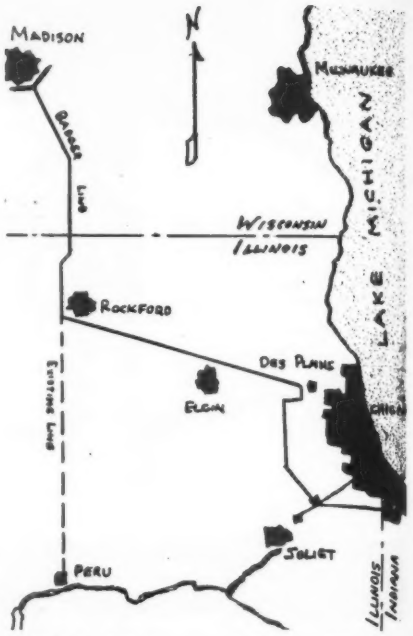
Northern's takes from its wells in the Kansas Hugoton field have been exceeding the "allowables" assigned by the Kansas Corporation Commission under the state's proration laws, and the new facilities are to be used to transport volumes of gas equal to the amount of the cutback to the allowable levels in the Kansas field.

Sinclair Operating New Houston-Port Arthur Line

Sinclair Pipe Line Company's new 83-mile, 12-in. products line running from Houston to Port Arthur, Texas, has begun operation.

Testing of the line and the pump station at Houston has been completed and products are now being moved from Sinclair's Houston refinery to the Evangeline System at Port Arthur.

The new line has a capacity of 54,000 bbl a day.



ROUTE of the proposed Badger Pipe Line Company, a 215-mile system which will give Wisconsin its first products pipe line. It will have 197 miles of 12-in. in and 18 miles of 10-in. line, with initial capacity of 65,000 bbl per day. Terminals will be located at Madison, Rockford, Des Plaines, and Southwest Chicago. An existing 8-in. line between Peru and Rockford will be purchased to extend the system 67 miles.

American Pipe Line Company Asks Tax Amortization

Application for an accelerated tax amortization certificate has been filed with the PAD for a products pipe line between Newark, New Jersey and Beaumont, Texas, by the American Pipe Line Company.

The project is similar to the recent United States Pipeline Company, PAD officials have related.

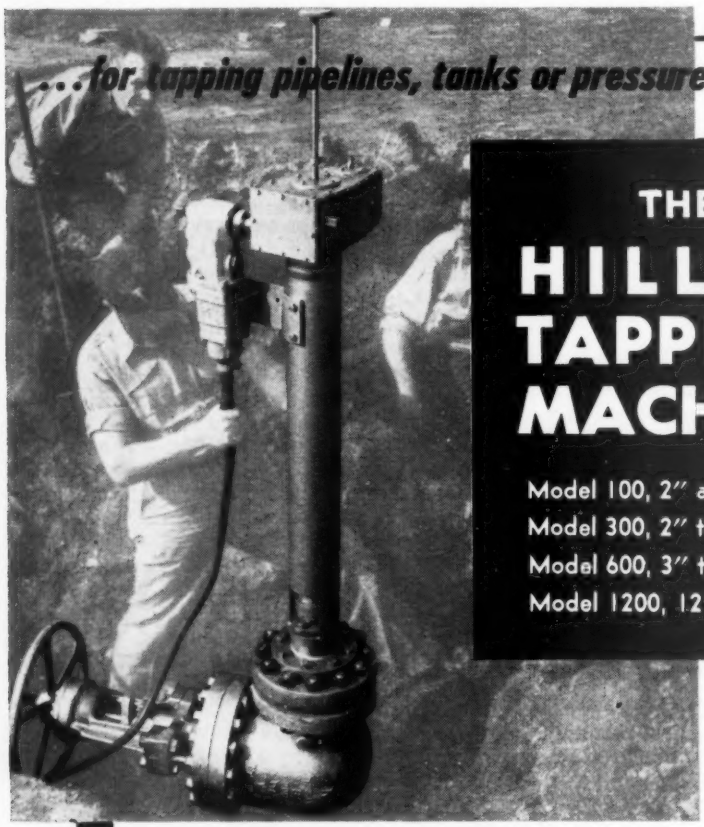
Barge operators recently filed suit against the United States Pipeline, charging it with attempted "monopoly" on oil movements up the Ohio River Valley. The bargemen requested the Department of Justice to withdraw an antitrust "greenlight" letter given the U. S. Pipeline.

220-Mile Parallel Line Planned by Pacific Gas

California's public utilities commission has authorized Pacific Gas and Electric Company to proceed with plans to build a 220-mile parallel natural gas pipe line at an estimated cost of $25,581,605.

The present line connecting PG&E with El Paso Natural Gas Company facilities has a capacity of 400,000,000 cu ft per day and will carry a total of 550,000,000 cu ft daily when present construction on the line is completed.

Addition of the new facility will give Pacific Gas another 150,000,000 cu ft capacity, for a total of 700,000,000 cu ft daily. The FPC recently approved an over-all plan for the increased capacity.



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Model 100, 2" and smaller
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Model 600, 3" to 12"
Model 1200, 12" to 24"

The HILLCO Tapping Machine is designed to tap high-pressure or high-temperature pipelines, tanks or pressure vessels (Oil, Natural Gas, Gasoline, or Water). For tapping through gate valves from ½" to 24" (Plug Valves 2" to 4", Special cutters are available for use with other valves having restricted openings). Larger sizes designed to operate with air motor. The HILLCO Tapping Machine is shop tested at 2000 p.s.i. for operation at 1000 p.s.i., and is also equipped with high-temperature packing.

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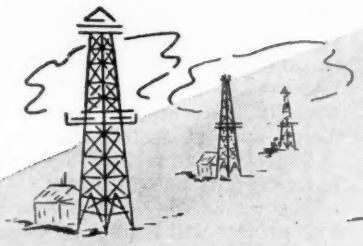
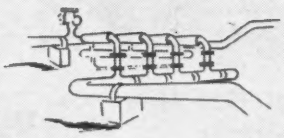


at the wells . . .



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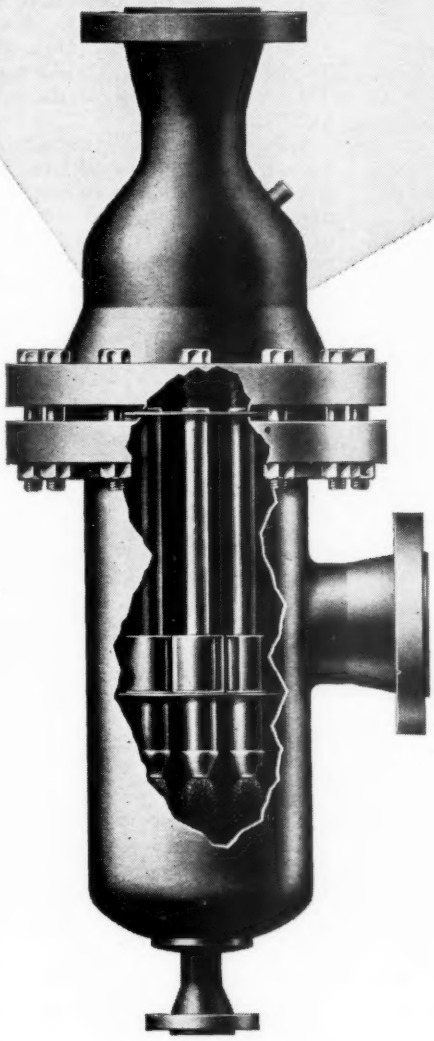

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The Aerotec Gas Scrubber uses no oil or other liquid as a filtering medium. This eliminates carryover and other normal disadvantages of conventional type scrubbers. By keeping the gas clean and dry, Aerotec units help prolong the life of compressors and reduce pipeline maintenance.

Aerotec precipitating tubes are the heart of this dry scrubber. Gas passes through these multiple, small-diameter tubes, and the foreign matter is separated from the gas by centrifugal force. Discharge is continuous.

Space-saving compactness, light weight, and piping simplicity of the Aerotec Dry Gas Scrubber permit easy installation. The standard units are available in practically any size up to 100,000,000 SCFD. Manifolding meets needs for larger capacities. Our representative will gladly recommend the Aerotec Scrubbers your specific gas-cleaning problem requires. Call or write today.

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Merger Authorization Asked by Two Companies

A request for authorization for the merger of Potomac Gas Company into Washington Gas Light Company has been filed with the Federal Power Commission in a joint application by the two companies. Potomac is a wholly-owned subsidiary of Washington, and both companies have main offices in Washington, D. C.

The application says that the proposed merger is part of a program for the unification of Washington and its subsidiaries. Washington's two Maryland subsidiaries — Prince George's Gas Corporation and Washington Gas Light Company of Maryland, Inc.— were liquidated on July 31, 1953, and the merger of Rosslyn Gas Company, which operates in Virginia, is expected to be effected in the near future, the application states.

12-Community Gas Line Service Asked for FPC

Northern Indiana Fuel and Light Company, of Auburn, Indiana, has asked the FPC for authority to construct a 35-mile, 10¾-in. pipe line to suply natural gas to 12 communities in Indiana, and also has requested the FPC to direct Panhandle Eastern Pipe Line Company, of Kansas City, Missouri, to supply it with natural gas for the proposed service.

The proposed pipe line would extend from a connection with Panhandle's system near Edgerton, Indiana, to Auburn, where it would connect with Northern Indiana's existing distribution system. Total estimated cost of the project, including conversion of Northern Indiana's customers' appliances to natural gas, is $876,814.

Northern Indiana now supplies manufactured gas to Auburn, Garrett, Altona, Avilla, and Kendallville. It proposes to serve Woodburn, Harlan, Grabill, Leo, Spencerville, St. Joe, and Waterloo.

20-In. Parallel Gas Line Slated for Kentucky

Temporary authorization has been granted to Central Kentucky Natural Gas Company, of Charleston, West Virginia, by the FPC for the construction and operation of 8.8 miles of 20-in. pipe line paralleling an existing line extending northward through North Means, Kentucky, to provide greater safety and continuity of service to the Cincinnati, Ohio, market area. The project is estimated to cost $706,300.

The temporary authorization is conditioned to limit Central Kentucky's combined total deliveries to Cincinnati Gas and Electric Company, of Cincinnati, Ohio, and Union Light, Heat and Power Company, of Covington, Kentucky, to 305,800,000 cu ft of gas per day pending final disposition of the application. The FPC said that the granting of the temporary authorization was without prejudice to disposition of application as record may warrant.

Cities Service Plans Gas Line Extensions

The FPC has issued a certificate to Cities Service Gas Company, Oklahoma City, Oklahoma, authorizing it to construct an extension to its pipe line system to attach additional supplies of natural gas in the Golden Trend area of central Oklahoma.

Cities Service will build a total of 69 miles of pipe and install one 1100 hp unit at an existing compressor station. The project will consist of 44 miles of 20-in. and 25 miles of 16-in. line, in Oklahoma, Cleveland, McClain, and Garvin counties, Oklahoma. Total estimated cost of the construction is $3,002,700.

11-Mile Line Authorized By FPC for California

The Federal Power Commission has authorized Pacific Gas and Electric Company, of San Francisco, California, to construct a total of approximately 11 miles of natural gas pipe line in the Pittsburgh, California, area. Total estimated cost of the project is $992,800.

Pacific will construct about 10½ miles of 24-in. pipe line from its Antioch control station to its steam electric plant at Pittsburg, and about 2500 ft of 24-in. pipe line to serve as a tie main between the western end of the 10½ miles of line and Standard Pacific Gas Line, Incorporated's, pipe line system at Stoneman Junction.

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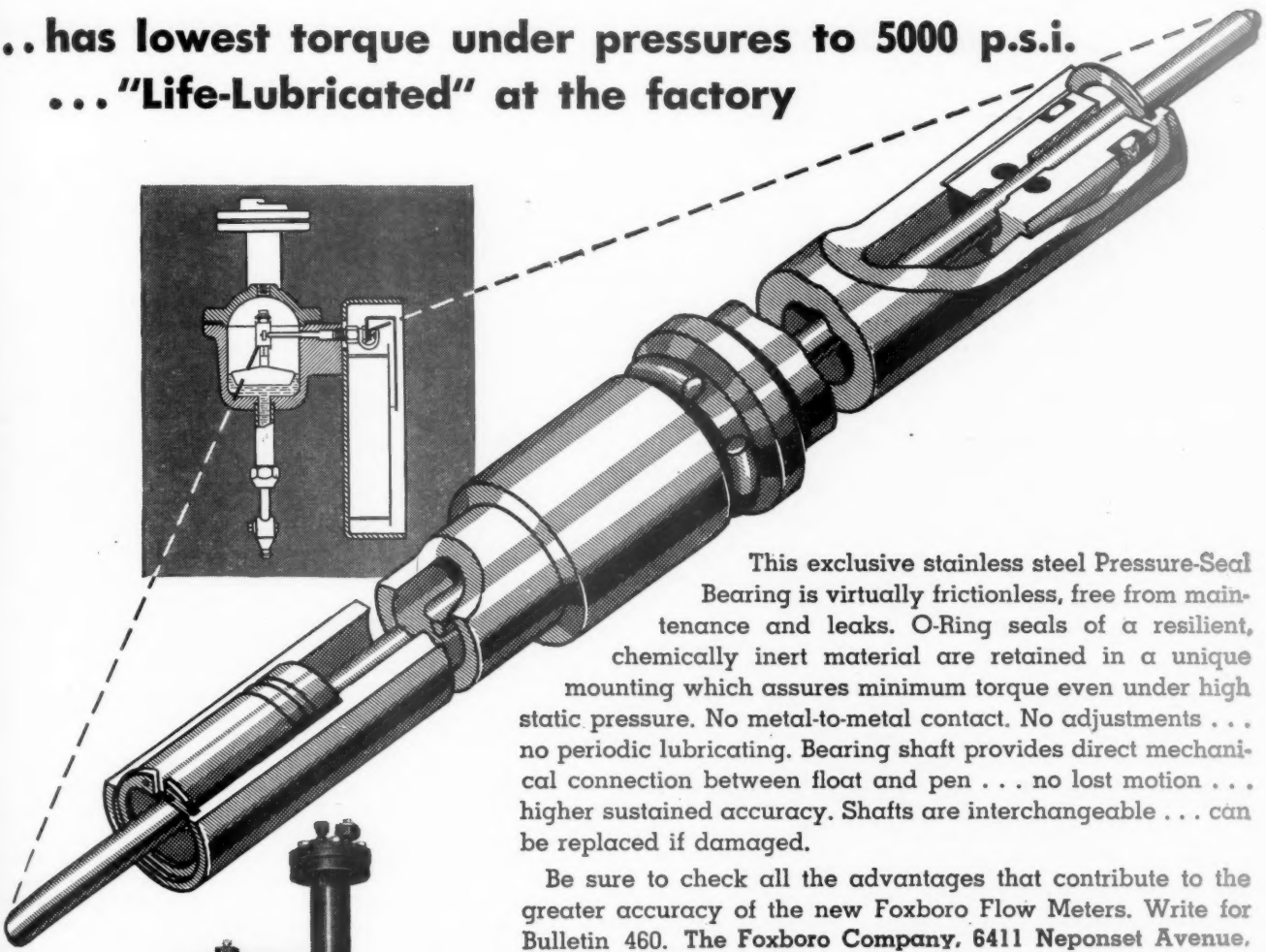

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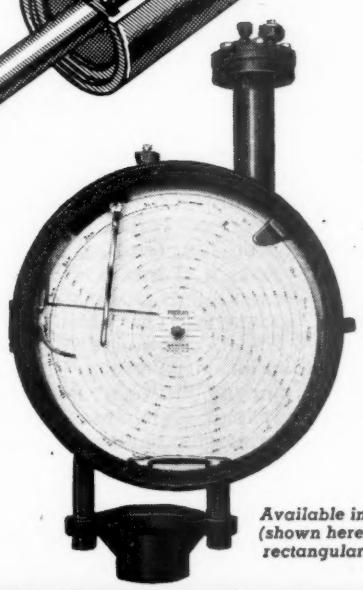

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WITH THE PIPE LINE CONTRACTORS

Associated Pipe Line Contractors, Inc., Houston, Texas, is working on 175 miles of 10-in. line from Bozeman, Montana, to Clinton, Montana, for Yellowstone Pipe Line Company. Jim Ed Andrews is superintendent and Buck Johnson office manager at the Bozeman field office.

Banister Construction, Ltd., 609 Northern Hardware Building, Edmonton, Alberta, Canada, has contract for 29 miles of 6- to 16-in. line for Socony-Vacuum between Fosterton field and a railway connection. Ray Oldfield is spreadman.

Company has completed 28 miles 1- through 6-in. for Alberta Consolidated Gas between Hanna and Hanna field. Company also has 11 miles of 1- to 4-in. for Saskatchewan Power Company, 8 miles of 4-in. for Imperial Oils Ltd., between Devon field and Bottery and undetermined amount of line for Royalite Oil Company.

Bills Construction Company, Tulsa, Oklahoma, is working on 8-in. line for Buckeye Pipe Line Company between Cartaret and Linden, New Jersey. Company also has river crossing on Rahway River. Carl W. Bills is superintendent and Kenneth Mills, welding foreman. V. Grizzell is office manager at the Plainfield, New Jersey, office.

Brown and Root, Inc., 4100 Clinton Drive, Houston, Texas, is working on 194 miles of 6, 8, 12, and 20-in. pipe line for Southern Natural Gas Company in the coastal area of Louisiana. From the Mississippi River east for a distance of approximately 144 miles, the spread is in charge of Jim Kincy, with field headquarters at New Orleans.

O. R. Burden Construction Corporation, P. O. Box 5216, Tulsa, Oklahoma, is constructing 153 miles of 12-in. and 16-in. crude oil line for Service Pipe Line Company between Tioga and Mandan, North Dakota. Two river crossings also will be installed. The field office is at Tioga. A. B. Haynes is superintendent and J. R. Perkins office manager.

Company also has approximately 51 miles of take-up for Sinclair Pipe Line Company on an 18-in. line in Missouri and Kansas.

Company has 65 miles of 10-, 12-, and 16-in. line in South Texas for Texas-Illinois Natural Gas Company.

Company has 45 miles of 18-in. line from Cushing to Shawnee, Oklahoma, for Sinclair Pipe Line Company.

Company has 24 miles of crude line in Montana for Texas Pipe Line Company.

Anderson Brothers Corporation, P. O. Box 2591, Houston, Texas, is completing 180 miles of 30-in. line being laid between the Michigan-Wisconsin state line to Cooks, Michigan, for Lakehead Pipe Line Company.

Construction of 82 miles of 14-in. between Charlotte and Greensboro, North Carolina for Plantation Pipe Line Company is near completion. Dick Bond is superintendent with headquarters at High Point, North Carolina.

Work has begun on 117 miles of 16-in. line from east side of Kalamazoo River, Michigan, to Wayne County, Michigan, for Wolverine Pipe Line Company. Dick Leonard is superintendent and W. W. Kirk office manager.

Company is working on approximately 70 miles of 3-, 4-, 12-, and 24-in. natural gas line for Gulf Interstate Gas Company in Louisiana. Glenn Allman is superintendent, with headquarters at Abbeville, Louisiana.

Company has 40 miles of 8-in. and 24 miles of 10-in. in New Mexico for Gulf refinery. Field office is at Lovington, New Mexico.

Lone Star Gas Company, Dallas, is working on a 44-mile, 12-in. line in Northeast Texas between Red Springs field and Sulphur Springs in Hopkins County. Directing construction is Luther Tolbert, Lone Star pipe line superintendent. Earl Miller is construction foreman.

Collins Construction Company, Victoria, Texas, has contract from Merritt-Chapman and Scott of India for construction of 84,000-ft of submarine line in the harbor at Bombay, India.

Eastern Pipe Line Contractors, 1801 Mercantile Bank Building, Dallas, Texas, has contract for two sections of the Yellowstone Pipe Line System between Billings, Montana, and Spokane, Washington. Eastern is building 158 miles of the 10-in. line. Two spreads are in operation, one working west from Clinton, Montana, and another east out of Murray, Idaho. A. L. "Bull" Stewart is superintendent and J. W. Arthur, office manager at the Missoula, Montana, field office.

El Paso Natural Gas Company, El Paso, Texas, has crews working on 300 miles of 4- to 16-in. gathering system lines near Bloomfield, New Mexico, at the Blanco field. Superintendent is Joe Self and B. R. Jones, office manager.

El Paso crews are also starting on 200 miles of 30-in. line from Winslow, Arizona, to Gallup, New Mexico. J. E. Lowry is job superintendent and J. S. Smith, office manager.

Foster Wheeler Corporation, 165 Broadway, New York 6, New York, has contract with North Atlantic Treaty Organization for management of 1920 miles of product line to be laid in Western Europe. The NATO pipe line network will have 4- to 10-in. lines and will cost $100,000,000.

Contracting and Material Company, 1235 Dodge Avenue, Evanston, Illinois, is constructing 20 miles of 30- and 36-in. line for Chicago District Pipe Line Company. A. J. Fry is superintendent and J. H. Myers office manager.

Conyes Construction Corporation, 2884 San Pablo Avenue, San Pablo, California, is finishing up 180 miles of 30-in. line for Lakehead Pipe Line Company.

Engineers Limited Pipeline Company, 225 Bush Street, San Francisco, California, is working on 90 miles of 34-in. for Pacific Gas and Electric in California.

G. G. Griffis Construction Company, 4450 East Admiral Place, Tulsa, Oklahoma, is working on three loops in Iowa for Northern Natural Gas Company. G. G. Griffis is general superintendent, Hook Miller spreadman, and R. H. Holmes, office manager at the Cherokee, Iowa, field office. The three loops are a 27-mile, 24-in. line, a 40-mile, 30-in. line and 32-mile, 30-in. loop.

C. W. Fowler, Cotton Valley, Louisiana, is working on 65 miles of 12-in. line and 10 miles of 8-in. line between Robstown and Seadrift, Texas, for Seadrift Pipe Line Company. R. G. Kemper is superintendent and W. G. Barnett office manager at the Refugio, Texas, field office.

R. H. Fulton and Company, P. O. Box 1526, Lubbock, Texas, is constructing 63 miles of 18-in. line for El Paso Natural Gas Company between Clear Creek and Provo, Utah. Superintendent in charge is Jerry Nash with Jack Frazer the office manager.

Fulton is working on 260 miles of 16, 20, 24, 26, and 30-in. line for the Permian Basin Pipe Line Company in loops from Hobbs, New Mexico, to Denver City, Texas, to Midland, Texas, to Rankin, Texas, and back to Hobbs. Oscar Phillips is superintendent at the McCamey, Texas, field office.

Underway also are 90 miles of 30-in. loop line for Permian Basin Pipe Line Company between Perryton, Texas, and Noals, Oklahoma. Vance Albers is superintendent and Claude Helweg, office manager.

Fulton also has 50 miles of 20-in. pipe between Hugo and Eads, Colorado, for Colorado Interstate Gas Company. Jim Gill is superintendent and Frank Tidwell office manager.

Also in progress are 250 miles of 30-in. line for El Paso Natural Gas Company between Corona and Gallup, New Mexico. A. A. Carrigan is superintendent and Bill Cohoon office manager for spread one; M. L. Boyd is superintendent and Charles Siewert office manager on spread two.

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Western Pipeline Constructors, Inc., has set a new standard of dependability for those who must have a constant supply of these priceless "underground" cargoes.

PIPE LINE WESTERN AUSTIN, TEXAS CONSTRUCTORS

James P. Neill, President — *Chas. S. LeNoir*, Vice-President — *E. G. Morrison*, Secretary

LOCKHART BUILDING • AUSTIN 2, TEXAS

XUM

CONTRACTORS

The Kuljian Corporation, 1200 North Broad Street, Philadelphia 21, Pennsylvania, has 11 miles of 4-, 16-, 20-, and 30-in. line at the Esso Standard, Intra-Refinery plant, Bayway. Engineers are R. F. Rundell, Charles Avon, Hiram Jones, John F. Pearce.

Government
AERIAL
Photography
and CONTROLLED MOSAICS for exploration operational plans, right-of-way, boundaries

Our integrated services of personal search, reporting, prepaid orders, and delivery follow-up usually saves you a month's delay and difficult correspondence with numerous gov't agencies on procurement of inexpensive stereo prints, controlled mosaics, etc. Often locates hard-to-find coverage. U. S. air coverage divided among various agencies and operating separately. Fees quoted on an assignment based on work necessary. Original gov't. prepayment receipts furnished; prints shipped you direct. If ready-made **Controlled Mosaics** not available for an area, can quote on CONTROLLED MOSAICS especially made from gov't photography by experts in photogrammetry. Searches for ready-made foreign air photography also made. WRITE DEPT. PE-1.

WASHINGTON COMMERCIAL CO.
Phone ADams 4-8060
1200 Fifteenth St. N.W., Washington 5, D. C.

Dunn Brothers, 801 Mercantile Building, Dallas, Texas, has the following hauling, stringing and unloading jobs:

154 miles of 16-in. for Magnolia Pipe Line Company's Ringgold-Corsicana line. Prime contractor is H. B. Zachry.

150 miles of 30-in. for El Paso Natural Gas Company between Denver City, Texas, and Corona, New Mexico. Prime contractor is Oklahoma Pipe Line Constructors.

164 miles of 30-in. for El Paso between Flagstaff and Kingman, Arizona. Prime contractor is Western Pipe Line Constructors.

355 miles of 30-in. for Gulf Interstate Gas Company between Kinkade, Tennessee and Kenova, West Virginia. Prime contractor is H. C. Price Company.

230 miles of 30-in. for El Paso between Winslow, Arizona, and Gallup, New Mexico. El Paso is handling own job.

Approximately 300 miles of 4- to 6-in. pipe for El Paso for a gathering system in the Farmington, New Mexico, area. El Paso doing own construction.

Engineering-Construction Company, 402 North Cheyenne, Tulsa 6, Oklahoma, is working on 94 miles of 16-in. line for East Tennessee Natural Gas Company between Knoxville and Kingsport, Tennessee. Also being laid on the same job are 56 miles of 4- through 12-in. line in laterals from the main line. Jim Williams is superintendent and J. W. Tyner, office manager, at the Morristown, Tennessee, office.

In the vicinity of Columbia, Tennessee, the company is working on 20 miles of 6-in. line. Curt Vaughan is spreadman and V. L. Bethel, office manager.

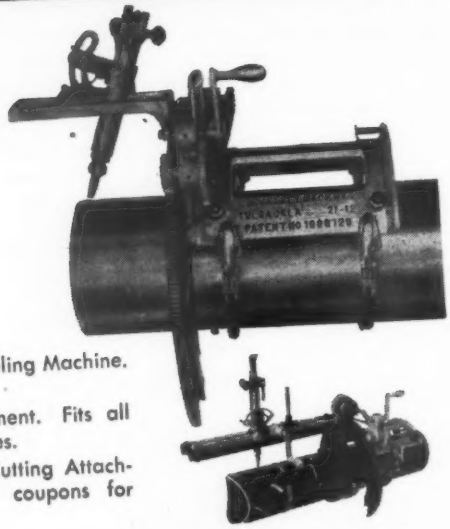
Jobs contracted for include construction of approximately 65 miles of 4- through 26-in. line near Elkhart, Kansas, for Colorado Interstate Gas Company and work for the city of Dallas, Georgia, on transmission and distribution lines. Earl Hackleman is spreadman and H. B. Hoge office manager on the Elkhart job. No starting date has been announced on the Georgia job.

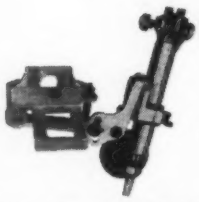
Holdran Construction Company, Mount Vernon, Illinois, is working on an undetermined amount of cross-country transmission lines and city distribution lines near Rock Island, Illinois, for Iowa Illinois Gas and Electric Company. H. W. Randall is superintendent and N. W. McGov office manager.

A. C. Holder Construction Company, 2615 East Admiral Place, Tulsa, Oklahoma, is working on 90 miles of reconditioning for a Humble-Chicago 6- and 12-in. crude line take-up and Pipe Line project between Buckner, Missouri, and Iola, Kansas. A. C. Holder is superintendent and J. D. Langley, office manager.

*Mathey
PIPE CUTTING AND BEVELING MACHINES

- **QUICKEST IN OPERATION**
  - Just slips over pipe
  - No hinges or latches to open or close
- **LIGHTEST WEIGHT**
- **FIVE MODELS** (for pipe from 4" to 36 inches)
- **ECONOMICAL**
- **FOR RENTAL OR PURCHASE**





Illustrated above: Mathey Pipe Cutting and Beveling Machine. Cuts pipe at any predetermined angle.
Illustrated left: Mathey Out-of-Round Attachment. Fits all sizes of Mathey (and Mathey-made) Machines.
Illustrated right: Mathey Shape and Coupon Cutting Attachment. For cutting pipe intersections and coupons for welding analysis.

*COMPLETE STOCKS OF PARTS FOR ALL MATHEY and MATHEY MANUFACTURED MACHINES IMMEDIATELY AVAILABLE

C. A. MATHEY MACHINE WORKS, INC.
212 SOUTH FRANKFORT ● TULSA, OKLAHOMA

Tellespen Construction Company, Houston, Texas, is constructing an underwater gas gathering system in Lake Maracaibo, Venezuela, for Creole Petroleum Company. The system will embrace about 14 miles of 24-, 26-, and 30-in. pipe.

Latex Construction Company of Georgia, P. O. Box 56, North Side Station, Atlanta, Georgia, is working on 36 miles of 14-in. pipe line for Southern Natural Gas Company in Alabama and Georgia. Field headquarters are in Port Wentworth, Georgia, with J. M. Phipps superintendent, Jim Davenport, spreadman, and A. C. Andrews office manager.

Houston Contracting Company, Ltd., 2707 Ferndale Place, Houston, Texas, has the following construction work:

Approximately 440 miles of 14-, 16-, 18-, 20-, and 24-in. natural gas lines for Southern Natural Gas Company in Georgia, Alabama, Mississippi, and Louisiana. Spreads now working as follows: Approximately 82 miles of 16-in. and 35 miles of 14-in. from Bass Junction, Georgia, to a point south of Wrens, Georgia. H. L. Leake, superintendent; S. B. Harrison, assistant superintendent; George A. Warner, field office manager; present headquarters, Milledgeville, Georgia. Approximately 105 miles completed. Approximately 120 miles of 14- and 16-in. in Georgia has been sub-contracted to Latex Construction Company of Georgia. Present headquarters, Sylvania, Georgia. Approximately 100 miles completed.

Approximately 500 miles of 30-in. natural gas line for Gulf Interstate Gas Company from Rayne, Louisiana, to Kinkade, Tennessee. Three spreads on this work as follows:

From Mississippi River going north, E. C. Norris, superintendent; R. E. Thornton, assistant superintendent; R. J. Axsom, field office manager; present headquarters, Water Valley, Mississippi. Approximately 90 miles completed.

From Ouachita River going south, R. L. Silar, superintendent; L. F. Redfearn, field office manager; headquarters, Jena, Louisiana.

From Ouachita River going north, M. L. Thompson, superintendent; J. B. Stoddard, field office manager; headquarters, will be in Winnsboro, Louisiana.

Parkhill Truck Company, P. O. Box 1856, Tulsa, Oklahoma, reports the following work:

Stringing 16-in. line pipe on the Wolverine line from East Chicago, Indiana, to a point near Marshall, Michigan, for Midwestern Constructors, Inc.

Stringing from El Dorado, Kansas, to Arkansas City, Kansas, 74 miles of 8⅝-in. pipe, and 130 miles of 10¾-in. pipe from Potwin to McPherson, Kansas, and Fairmount, Nebraska, for Ray L. Smith and Son, Inc.

Hauling 30-in. pipe for Gulf Interstate Gas Company from Houston and Orange, Texas, to storage points in eastern Louisiana and Mississippi.

Hauling, storing where necessary, and stringing approximately 303 miles of 12-in. pipe from White River to Allen, Oklahoma, for Sunray Oil Corporation. Contractor, River Construction Corporation. Also approximately 97 miles of 10-in. pipe from Allen, Oklahoma, to Duncan, Oklahoma.

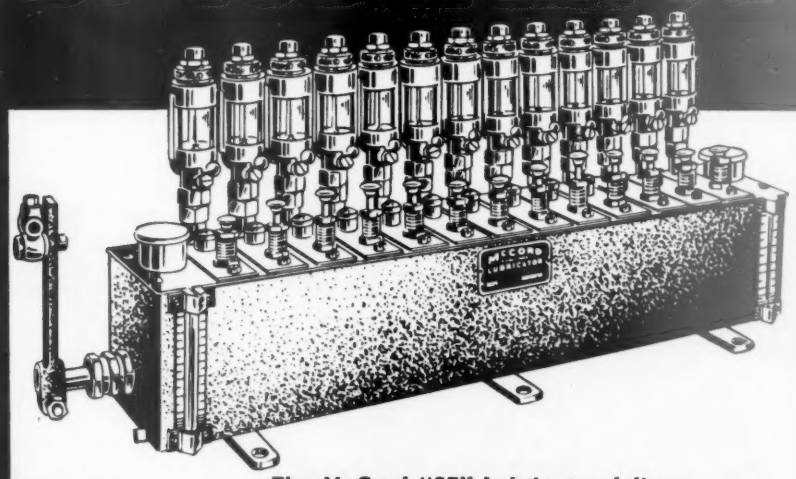
Unload, haul and string approximately 13 miles of 16-in. and 29 miles of 12-in. pipe for Gulf Interstate gathering system in Louisiana. Contractor, Associated Pipe Line Contractors, Inc.

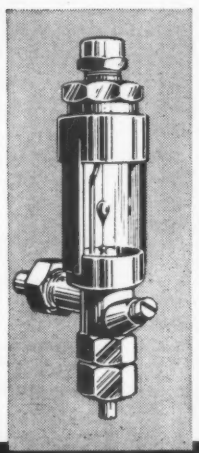
Hauling and stringing approximately 12 miles of 16-in. coated pipe from Romulus to Dearborn, Michigan, for R. B. Potashnick Company, contractor.

Somerville Construction Company, Ada, Michigan, has 35 miles of 4 to 24-in. line for Michigan Consolidated Gas Company near Six Lakes, Michigan.

Ray L. Smith and Son, Inc., Hazlett Building, P. O. Box 391, El Dorado, Kansas, is constructing 280 miles of 8- and 10-in. products line between Arkansas City, Kansas, and Fairmount, Nebraska, for Kaneb Pipeline Company and Augusta Pipe Line Company. Two spreads are in operation. R. M. Jones is superintendent and Tom Davis office manager for spread one, and Dewey Whitworth is superintendent and D. L. Marley office manager on spread two.

McCORD "Tubular Clearsite" Feed
SF LUBRICATOR





The McCord "SF" Lubricator delivers a predetermined quantity of oil under pressure at regular intervals to cylinders or bearings. A new improved tubular clearsight feed, a McCord development, shows delivery and quantity of oil. It may be cleaned without removing from pump. Other McCord advantages are easy removal of pump units, welded steel tanks, wide variety of drives, and a new graduated oil level gauge providing greater visibility. McCord offers you an outstanding lubricator, further improved to provide better service. Deliveries are prompt.

LUBRICATOR DIVISION
McCORD CORPORATION
Detroit 11, Michigan

CONTRACTORS

H. C. Price Co., Pipeline Division, P. O. Box 1111, Bartlesville, Oklahoma, has the general contract covering construction of approximately 355 miles of 30-in. high pressure natural gas pipe line for Gulf Interstate Gas Company starting at a point near Gordonsburg, Tennessee, and extending northeasterly to a point near Catlettsburg, Kentucky.

Sheehan Pipe Line Construction Company, 529 National Bank of Tulsa Building, Tulsa, Oklahoma, has 9 miles of 12-in. between Pauls Valley and Rosedale, Oklahoma, for Sinclair Pipe Line Company. J. W. Brown is superintendent.

Panama-Williams Company, 1417 Melrose Building, Houston, Texas, has contract for approximately 65.6 miles of 4½- through 12¾-in. line for The Texas Pipe Line Company in south Louisiana, including six gathering pump stations to be mounted on piling over water and one station on land.

Company has 80 miles of 10-in. take-up for Humble Pipe Line Company between Longview, Texas, and the Texas-Louisiana state line.

Company has 43 miles of 24-in. between Edna and Wharton, Texas, for Houston Pipe Line Company.

Company has 7 lines, three 12-in. and four 8-in. under the Houston ship channel crossing for Shell Pipe Line Company. All lines are a single ditch and will be pulled at the same time.

Midwestern Constructors, Inc., 105 North Boulder, Tulsa 3, Oklahoma, has completed 97 miles of 30-in. pipe line between Cooks and St. Ignace, Michigan, for Lakehead Pipe Line Company.

Work on 153 miles of 16-in. line east side of Kalamazoo River in Michigan to Kennedy pump station at East Chicago, Indiana, for Wolverine Pipe Line Company is near completion. M. T. Wilhite is superintendent, John Petty, spreadman, and A. T. Tolbert, office manager. Office is at Battle Creek, Michigan.

Oklahoma Pipe Line Constructors, 6612 Harry Hines Boulevard, Dallas, Texas, is laying approximately 150 miles of 30-in. for El Paso Natural Gas Company between Denver City, Texas, to a point near Roswell, New Mexico. Two spreads are working on the job. Louis Visentine is superintendent of spread one. E. R. Law is superintendent of spread two and Gene Gohring is assistant superintendent. R. F. Mueller is office manager and Geno Gallina purchasing agent at the Lovington field office.

Western Pipe Line Constructors, Box 798, Austin, Texas, is working on 164 miles of 30-in. line for El Paso Natural Gas Company between Kingman and Flagstaff, Arizona. Benny Williams is superintendent and P. O. Rutledge office manager at the Williams, Arizona, field office.

H. B. Zachry Company, Box 2570, San Antonio 6, Texas, is working on 154 miles of 16-in. pipe between Ringgold and Corsicana, Texas, for Magnolia Pipe Line Company. Two spreads are in operation. D. B. Shrum is superintendent and Ray Shields office manager of spread one at Ennis, Texas. W. L. Huff is superintendent, and D. Trice office manager at spread two.

River Construction Corporation, 6100 Bowie Boulevard, Fort Worth, Texas, is taking up 1600 miles of 8- and 12-in. line for Sinclair Pipe Line Company in Kansas, Missouri, Illinois, and Indiana.

Work on 107 miles of 22-in. line from Bunkie to Shreveport, Louisiana, has started. Jim Reed is superintendent and Pat Rogan office manager. On one spread, field office is at Melville, Louisiana. T. M. Tatom is superintendent and Lee Price office manager at the other spread, office is at Natchitoches, Louisiana.

Company has 73 miles of 30-in. line in Riverside County, California, for Southern California Gas Company.

Company has contract for 303 miles of 12-in. and 97 miles of 10-in. for the Oklahoma-Mississippi River Products Pipe Line, Inc.

Merritt-Chapman and Scott, 260 Madison Avenue, New York 16, New York, has contract for pipe line system in India to link two refineries under construction at Bombay, India.

PIPELINERS
depend on
MAVOR-KELLY
PRODUCTS
BITUMASTIC
HOT & COLD APPLIED COATINGS
Carey
PIPELINE FELT & PADDING
TAPECOAT
PIPE JOINT PROTECTION
AVAILABILITY
Mavor-Kelly always maintains adequate stocks and gives immediate attention to your order.
SERVICE
Mavor-Kelly service is dependable. Our traffic department "follows through" completely on all shipments to give you on-time delivery.
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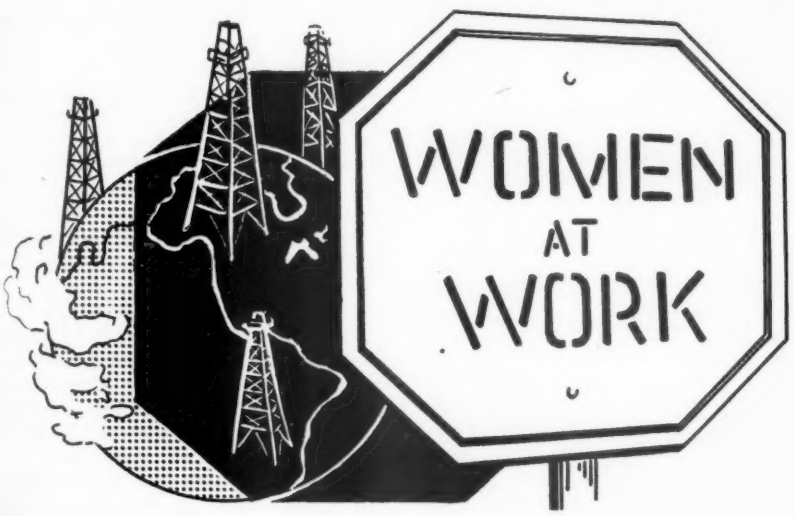
Phone CApitol 2203 M. & M. Building

Alamae Herndon of Grisham-Hunter was a high school graduate and beginning her career at age 15.

Muriel E. Reynolds introduced to stockholders of Standard Jersey in 1951 by Chairman of the Board F. W. Abrams.



Prodigy Enters Oil

On February 15, 1945, the newest employee of Grisham-Hunter Oil Corporation, Abilene, Texas, took a letter that described all the formations in Culberson County, Texas. It was an excellent outline of the oil industry in West Texas and a good introduction to her new profession for **Alamae Herndon.** Since that day she has been a loyal and enthusiastic booster for the oil industry and for her company.

But then Alamae Herndon has always been enthusiastic. She waited until she was 15 to get her first job. She was a high school graduate with three months business training when she went to work for a doctor and for two years she took care of the office, attended classes at Abilene Christian College in the mornings, and worked as a nurse's aid in the evenings.

And she had time to fall in love and marry Leo Herndon! They spent a short time in St. Louis, then early in 1945 while her husband was in service, Alamae returned to Abilene and joined Grisham-Hunter. She has been almost continuously employed by the company since that time.

Mrs. Herndon is office manager for Grisham-Hunter — a job that takes in "any task that needs my attention." She supervises the work done by the other women in the office, does accounting, drafting, dictating correspondence and contracts, assisting in title curative matters, setting up land records, analyzing various trades, and any other work that comes to hand. She is a division secretary for the Dale Carnegie Club International, is a member of the Abilene Desk and Derrick Club and of the Northside Church of Christ. Most of her off-duty hours are devoted to Leo and a son, Pat.

275,000 Bosses

Muriel E. Reynolds is a corporate officer of the largest oil company in America, proving that big companies as well as small ones are making use of woman power. She is assistant secretary of Standard Oil Company (New Jersey) and has one of the most interesting positions in the organization. She works in the field of management stockholder relations, no small job considering Jersey Standard has more than 275,000 owners.

Miss Reynolds began her business career while she was in high school when she became a part-time bank clerk. After graduation from Wheaton College, Norton, Massachusetts, in 1924 she taught school in New Jersey for a year and then worked for a brief time at Western Union.

Muriel Reynolds' next job was with Jersey Standard. Starting as a stenographer, she became secretary to an officer, later an administrative assistant, and in September 1945 was appointed an assistant secretary of the company.

In addition to her company duties, Miss Reynolds has a busy personal life. She is a trustee of Wheaton College, a member of the New York City branch of the American Association of University Women, vice president of the New York City chapter of Zonta International and a former member of the board of managers of the Women's University Club. She has an interesting and unusual hobby; it is collecting old maps.

Nine Olds in Olds Oil Company.

Family Business Is Oil Business

Mary Olds in a partnership with her father and seven brothers in the Olds Oil Company. She and one brother, R. M. Olds, operate the Casper, Wyoming, office, which is Olds Oil Corporation, a subsidiary of Great Lakes Oil and Chemical Company of Los Angeles, California. The others run the home office in Mt. Carmel, Illinois, where the company was formed in 1941.

During the war, Mary spent three years as a civilian employee of the

Catawissa
PERFECT SEAL
Unions

HOT FORGED from solid, rectangular steel bars, designed and produced for dependable, long-life service under the severest piping conditions!

A TYPE FOR EVERY USE!
FOR ALL PRESSURES!
FOR ALL TEMPERATURES!

Standard & Double Extra Heavy
UNIONS
Available with screwed or socket weld ends. 3000-lb. sizes 1/8" to 3"; 6000-lb. sizes 1/8" to 2".

ORIFICE UNIONS
With screwed or socket weld ends. 3000-lb. and 6000-lb. service.

MALE & FEMALE UNIONS
With steel-to-steel, bronze-to-steel, stainless steel-to-steel or orifice seats. 3000-lb. service only.

Standard & Double Extra Heavy
LUG NUT UNIONS
Hammer-type for quick opening and quick closing.

write for your free copy of
CATALOG 11
for complete information
CATAWISSA VALVE AND FITTINGS COMPANY
750 Mill St. • CATAWISSA, PA.

Army Medical Corps in San Francisco.

When Olds Oil Corporation opened the Casper office back went Mary to the family firm. She is assistant secretary of the corporation. She draws contracts and letter agreements, invoices for these contracts on such things as footage, drilling time, drill pipe rental, casing, tubing, etc. Her other responsibilities include handling the payrolls and payments on royalty and on working interest to other interest holders from their production. All monthly reports on oil production, trucks, and insurance are made by the girl partner.

It was natural that Mary should help organize the Casper Desk and Derrick Club and be its first president. She is an enthusiastic oil woman and a willing worker in Business and Professional Women's Club, Women's Division of OIIC, Civil Air Patrol, BPOE Does, Order of the Eastern Star, and of the Presbyterian Church.

Music lost charm for Frances Duerr.

Musician Becomes Oil Hit

Educated to be a musician, **Frances L. Duerr** got into the oil business by accident and remained in it by choice.

"When I was quite young," she says, "my parents decided I should have a musical education, so I began taking piano lessons and graduated from the M. A. Monzel School of Music. While I was in high school my father thought I should take a commercial course — since, he said — musicians usually make poor business managers."

Frances had her commercial course and it was this turn of events that eventually took her into the oil business. Just after she graduated from high school a friend of her father's asked her to take a summer job with him as a stenographer. Some months later he joined Sinclair Refining Company in charge of the accounting department. He prevailed on Frances to go with him.

That was on August 5, 1918. Frances L. Duerr has been with Sinclair ever since. In addition to stenographic duties she handled the office and field payrolls in the early days. In 1925 she became secretary to J. M. Judson, general credit manager for Sinclair, and remained in that position until Judson retired in 1942. She is now secretary to H. M. Allen, district credit manager, Central district.

Sounded crazy to Olivia Starken.

"I've always enjoyed swimming and horseback riding though I've found little time for either since my husband and I bought a home a few years ago." Mrs. Duerr, who has always had a flare for interior decorating, and her husband, whose hobby is woodworking, concentrate on making things for their home. The combination makes for enjoyable after-office hours in the Duerr home in Hinsdale, Illinois.

Tri-State Oil Expert

Olivia Starken is a tall willowy blond with a yen for adventure and a pen for oil. In the past decade and a half she has managed to mix both with a happy marriage that has lasted 21 years.

A native of Mt. Vernon, Indiana, she moved with her family to Evansville at an early age. There, at an age when most of her friends were just beginning to get interested in boys and with only one semester of high school typing to recommend her, Olivia went to work. Her first job was in a letter shop and her ability soon advanced her to the position of office manager.

In 1938 Jerry Robertson, whom Mrs. Starken remembers as a "small man in a 10-gallon hat," breezed into a Tri-State oil report. It was an intriguing idea to Olivia, though her boss still declares she cut and ran the stencils of that first report muttering under her breath: "It sounds crazy to me."

The idea that sounded crazy to Mrs. Starken has been her pet project ever since. For the past ten years she has been in full charge of Jerry Robertson's office directing a staff of ten. In addition to the Tri-State Oil Report, she does a column for the Evansville Courier called "Oil Drilling, Developments in Tri-State Fields." She also aids Mr. Robertson in writing newspaper articles and in doing creative writing. They have just co-authored a book for the layman called "ABC's of Oil."

In addition to her writing and editing, Mrs. Starken is president of the Tri-State Desk and Derrick Club which she helped organize; is chairman of the Women's Division in her region for OIIC and is a member of American Association of Petroleum Writers.

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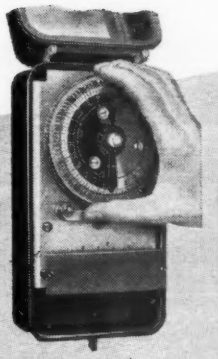
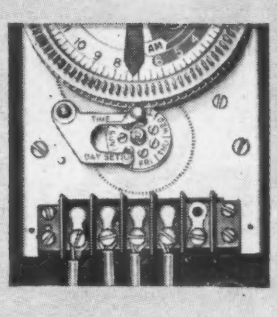


Cutler-Hammer Program Time Switch gives automatically scheduled pumping, set up easily by means of pull tabs—one for each 15 minute interval.



Day-omission feature—for non-operation any selected days of week.

Cutler-Hammer 9589 Oil Well Pumping Controller with 3 coil overload protection and time delay relay.

ONE TRIAL WILL TELL YOU

It's Genuine

Oil Country Control

You'll only have to make a comparison *once* to see why Cutler-Hammer Oil Well Pumping Control is called *the* Oil Country Control and to see why oil men are installing it in preference to any others.

It is the outcome of a genuine, thorough and sincere contact with oil country conditions; with oil men's wishes. Not just to start, stop and protect motors and equipment successfully and dependably . . . but to meet and beat the oil country enemies of good performance . . . heat, humidity, static, dirt, dust, bugs, prevalent single phasing, sometimes careless handling.

Take a look at C-H. Note the ventilating openings that create a chimney draft to keep the "works" cool. Note the aluminum coating that bounces back the sun's rays. Note the out-in-the-open contacts that stay cooler and being "vertical," shed dust.

Note how all openings are screened, baffled, louvred to keep out dirt and dust, and bugs. See how Neoprene gasketing keeps dust out of the timer how the excess torque clock motor keeps "ticking" away even if dust gets in.

Take a look at the scheduling mechanisms, the easy on-off scheduling in 15 minute increments, the automatic day-omission feature. And there's manual or automatic restarting after an outage, either all at once or staggered starting.

Here's a popular feature too . . . optional 3 coil overload protection where single phasing is a problem; standard 2 coil where it is not a problem.

Note you don't have to rebuild or clean up the starter after a lightning arrester blows.

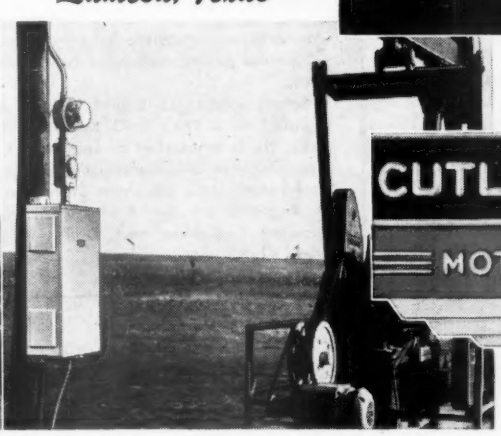
These are but some of the features that make this starter stand out like a derrick on a flat plain. Once you try it, you'll keep on using it.

CUTLER-HAMMER, Inc., 1459 St. Paul Ave., Milwaukee 1, Wis. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.

Snyder, Texas

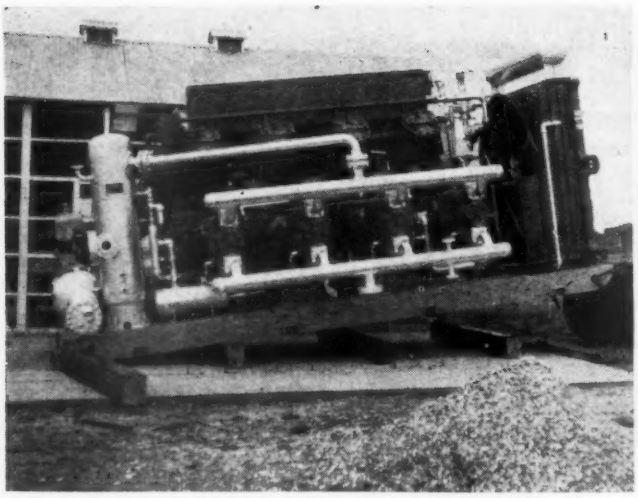
Oilton, Okla.

Lamesa, Texas

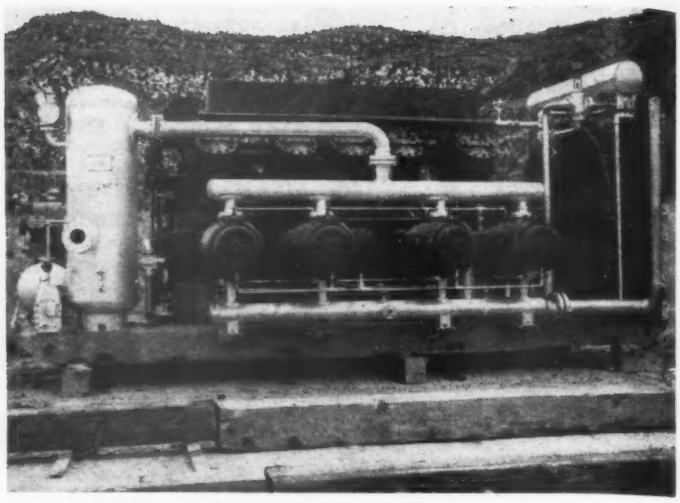


CUTLER-HAMMER
MOTOR CONTROL
C-H

MEMBER AMERICAN PETROLEUM INSTITUTE



THIS 440-HP packaged compressor is being lowered onto a light concrete slab which is the only foundation it requires. It was trucked from factory to location as a complete, fully assembled plant.



THIS 550-HP packaged compressor plant is first of three to be installed in a remote New Mexico field. Automatic controls permit units to operate unattended for a minimum of 72 hours in the event of bad weather.

Economics of Packaged Compressor Plants†

Modern units are adaptable to gas or air compression; may be used as one or in banks of several; reduce installation and maintenance costs

E. S. McROBERTS

If you were to take an entire compressor station of a major pipeline, with its compressors, cooling equipment, lubricating system — all its manifolds, piping, scrubber and starting air system, assemble these in a factory on a rigid fabricated steel base, and add a number of additional automatic safety controls — you would have a "packaged compressor plant."

It would include not only all these parts and components, but it would have behind it a careful job of engineering — both mechanical engineering and process engineering. For in a packaged compressor plant, proper design, layout and sizing of parts is as essential as it is in a large stationary compressor station.

Complete packaging is a great deal more than just skid mounting or packaging a compressor — it is packaging an entire plant. Even though it is wholly complete and fully assembled, it must be so compact in design that it can be transported by oil field trucks directly to the installation site. And it must be so ruggedly built that it will require little attention and stay in service for a life time. We refer here only to heavy duty, direct connected, gas engine driven compressor plants.

These packaged plants have a variety of applications in oil and gas production as well as in other fields. For each one is individually designed and may be adapted to any use where gases or air must be compressed.

Let's take a look at a few of these applications. In the production of oil, wells eventually lose their pressure and require artificial means of lifting oil from the formation to the surface. A number of years ago it was discovered that this could be done by what is known as a "gas lift", using residue gas from the field to literally push the oil up out of the hole. If the gas pressure was not sufficient, however, a compressor plant had to be installed to make gas lift possible.

Today, with the development of special gas lift valves and the packaged compressor plant, this method of production is gaining favor. It is proving especially popular in areas where wells are deep. For when you try to pump oil out of a deep well, you have a great loss of pump efficiency, due to the fact that sucker rods stretch and sometimes the amount of stretch is almost the stroke of the pumping unit.

Another very important use of the packaged compressor plant is in the saving of flush production gas from new oil wells. Most state regulatory bodies

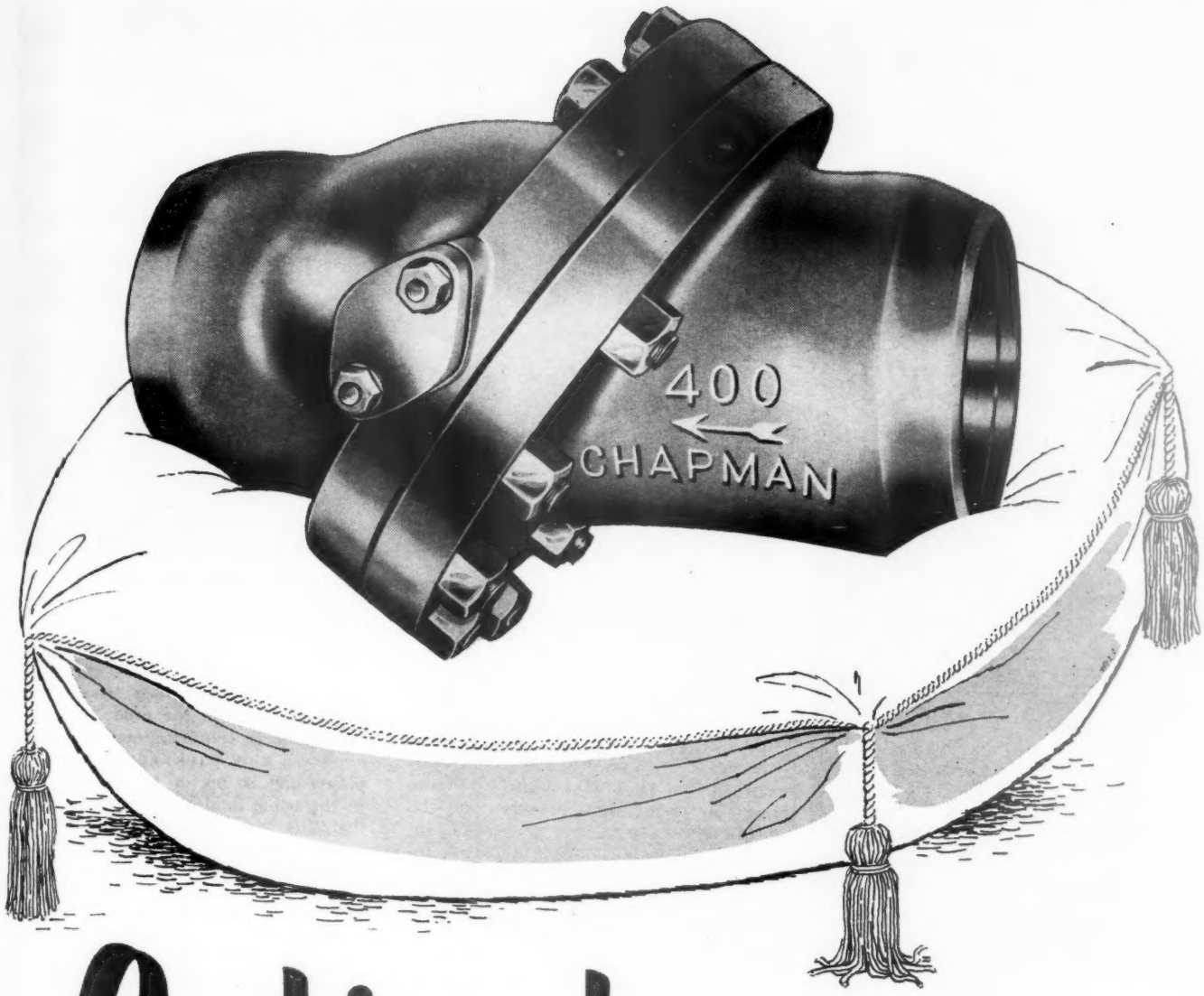
The Author

E. S. McRoberts is manager of sales of packaged compressor plants at The J. B. Beaird Company, Inc., Shreveport, Louisiana. He has been associated with the company for 10 years, having formerly held the position of assistant chief engineer. In that capacity he was largely responsible for original development of the packaged compressor plant.

Before coming to Beaird he was associated with Frick-Reed Supply Company. He is a member of Louisiana Engineering Society, American Ordnance Association, API, Louisiana State Board of Registrations for Professional Mechanical Engineers and Dallas Engineers Club.

†Presented at the ASME meeting at Houston, Texas, September 27-30, 1953.

XUM



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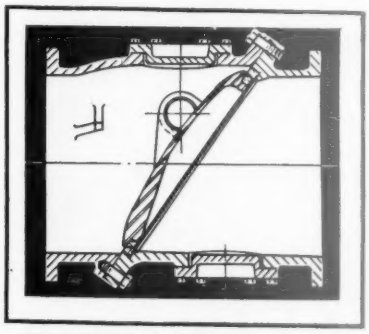

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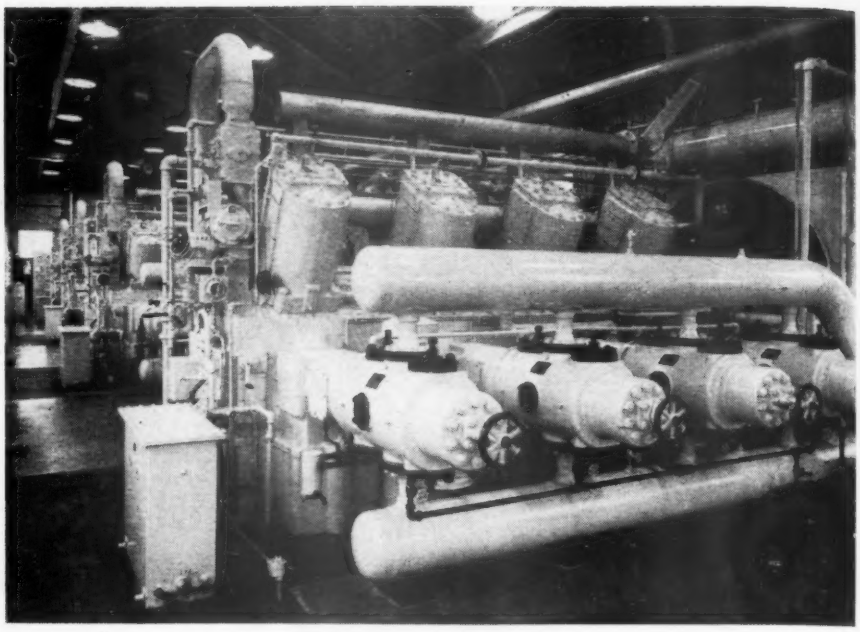


BANK of four 440-hp packaged compressor plants boosts field gas from a gathering system up to pipe line pressures. Each unit is a complete plant, assembled at factory on its own specially formed steel base.

will allow increased oil production if this gas can be saved. If there is a gas line available nearby, it can be compressed to line pressure and sold. Otherwise, it can be pumped back into the reservoir to maintain pressure and the flowing life of the field prolonged. Increased allowables mean increased income for the oil producer and the packaged compressor plant under these circumstances will usually pay for itself in a very short length of time.

But the packaged plant has found its greatest use so far in the production of gas. As gas gathering systems have reached farther and farther into new fields, it has become necessary to maintain reasonably high line pressures, and, at the same time keep gas flowing into these lines from all wells in the fields.

When field pressures begin to fall, some wells will not flow into the gathering lines at all. Others will have their flow sharply reduced. Usually these wells are fairly well grouped so that two or three or even many more may be tied into one field compressor and the gas compressed to pipe line pressure.

This is far more economical than lowering line pressures in the field and installing compressors in the gasoline plant. For, in this event all of the gas from the field must be compressed, while only a small per cent — say 10 per cent — may actually require it.

If a compressor were centrally situated at the plant to handle an entire field, it would also be necessary to install a new field gathering system. For example, a line designed to carry a given volume of gas at 1400 or 1500 psi would handle a far smaller volume at 200 or 300 psi.

There would also be a saving in the compressor installation itself by using smaller field compressors near the wells. Less overall horsepower would be required to deplete the field, because as the first wells requiring compression are depleted, the packaged compressor plants can be moved to other locations in the same field and reused. I believe that this one feature would result in a saving estimated conservatively at 25 per cent and possibly more.

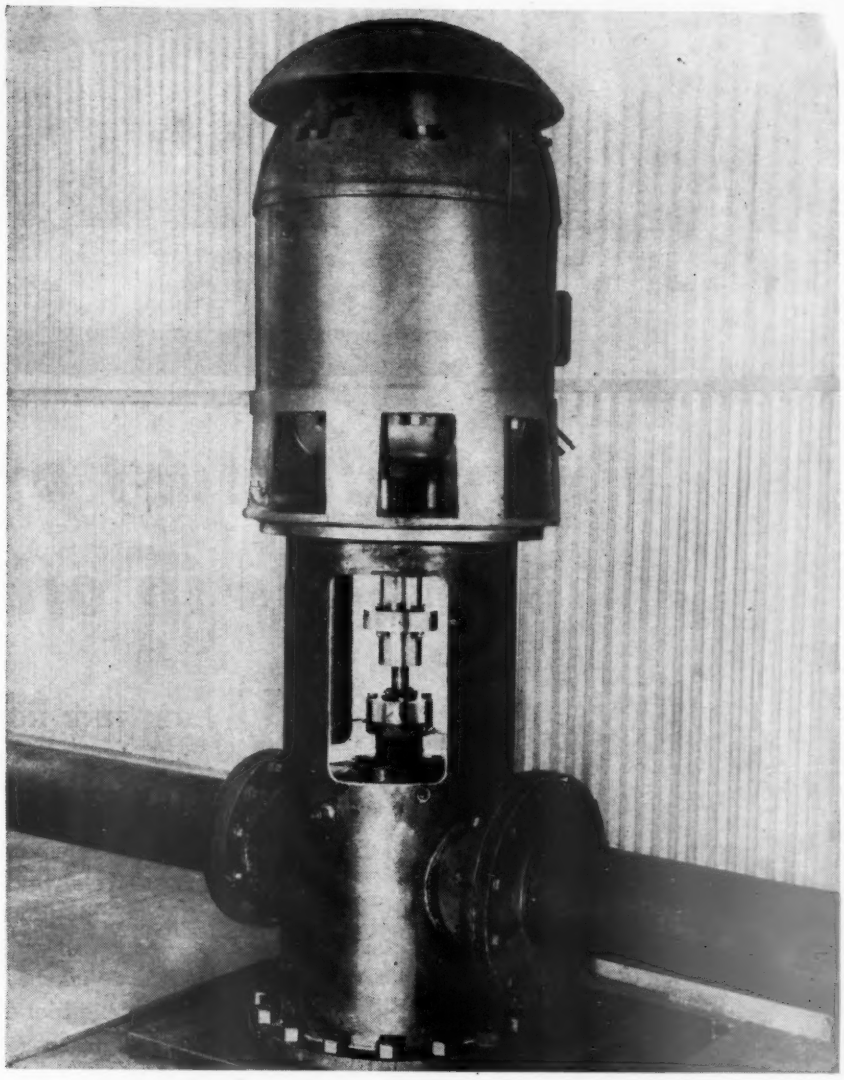
Another economy of the packaged compressor plant in gas boosting is its ability to handle varying load conditions with very little change. For example, the plant is usually a single-stage unit when installed. That is, all of its compressor cylinders have the same suction pressures and the same discharge pressures.

These cylinders are sized to permit operation at a suction pressure equal to or slightly less than the discharge pressure, but large enough to permit operation until the suction pressure has declined to such a point that single stage compression can no longer be used efficiently.

When this time arrives the change to two-stage compression can be made by adding one, or at the most, two new cylinders for the first stage, installing a gas intercooling coil on the radiator, and mounting a second stage scrubber. The cost of such a changeover is held to a minimum, because in the basic design, provision had been made to accommodate this equipment. With the exception of the new compression cylinders, the cost will be no greater than if it had originally been purchased as a two-stage plant.

In the conservation of natural gas, the packaged compressor plant has played a large part. Not too many years ago gas was considered a necessary evil in the production of oil, to be separated from the crude oil the best way possible and disposed of by burning.

In Large Refineries and Small...



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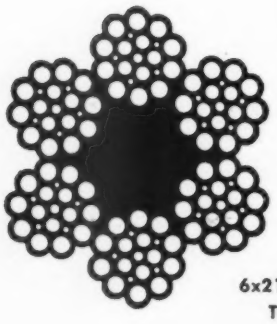
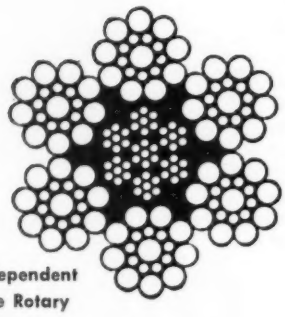


6x21 Filler Wire Cable Tool Drilling Line

6x7 Sand, Coring or Swabbing Line



6x19 Seale Independent Wire Rope Core Rotary Drilling Line

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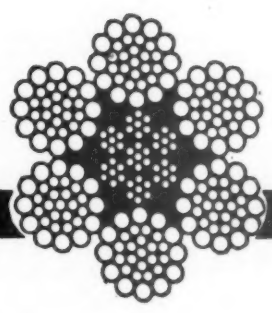

6x31 Seale Independent Wire Rope Core Tubing and Winch Line

1236

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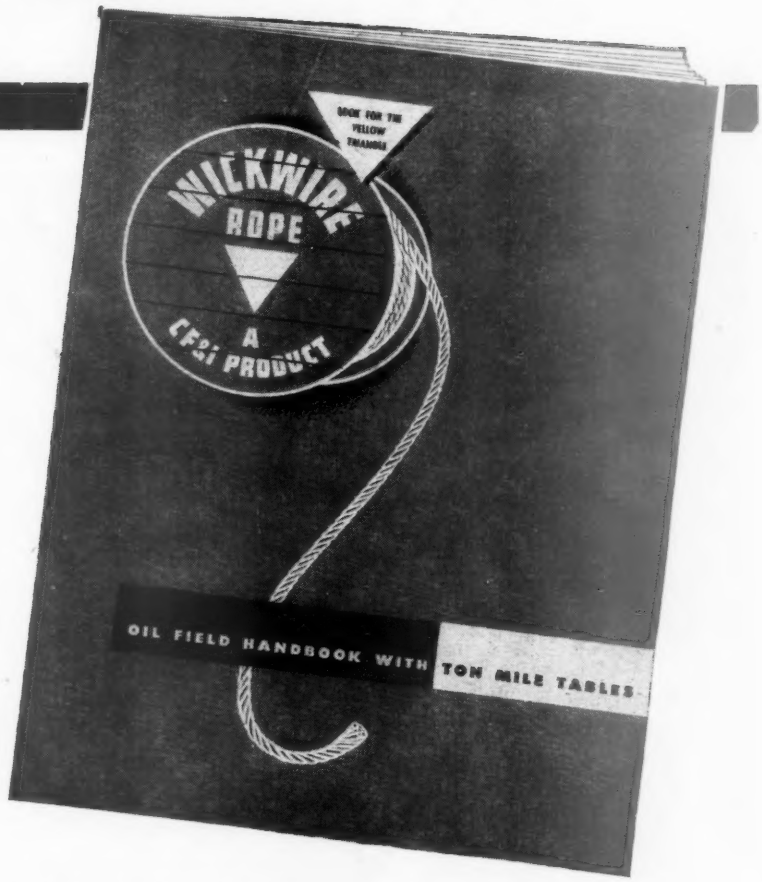

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For some of it had a bad habit of settling in low places where it was likely to explode when some unsuspecting person struck a match. Now we know that the part that settled out was the butane or propane fraction that has a specific gravity greater than air.

During this time, especially in isolated areas, gas wells were plugged.

Later, the gasoline plant was developed to recover from wet gas the natural gasoline, or, as it is generally called, casinghead gasoline. Gathering lines were laid into fields where the GPM content was relatively high. Separator gas was brought to the gasoline plant and stripped. The residue gas was returned to the leases for fuel or any other local uses for which gas might be required.

Usually, producers required only a very small portion of this residue gas for such purposes, so the gasoline plant flared what was left. The producer was paid on the GPM only.

Today, with the packaged compressor plant in use, this residue gas may be utilized for gas lift, repressuring, or for delivery into the gathering system of a gas transmission line.

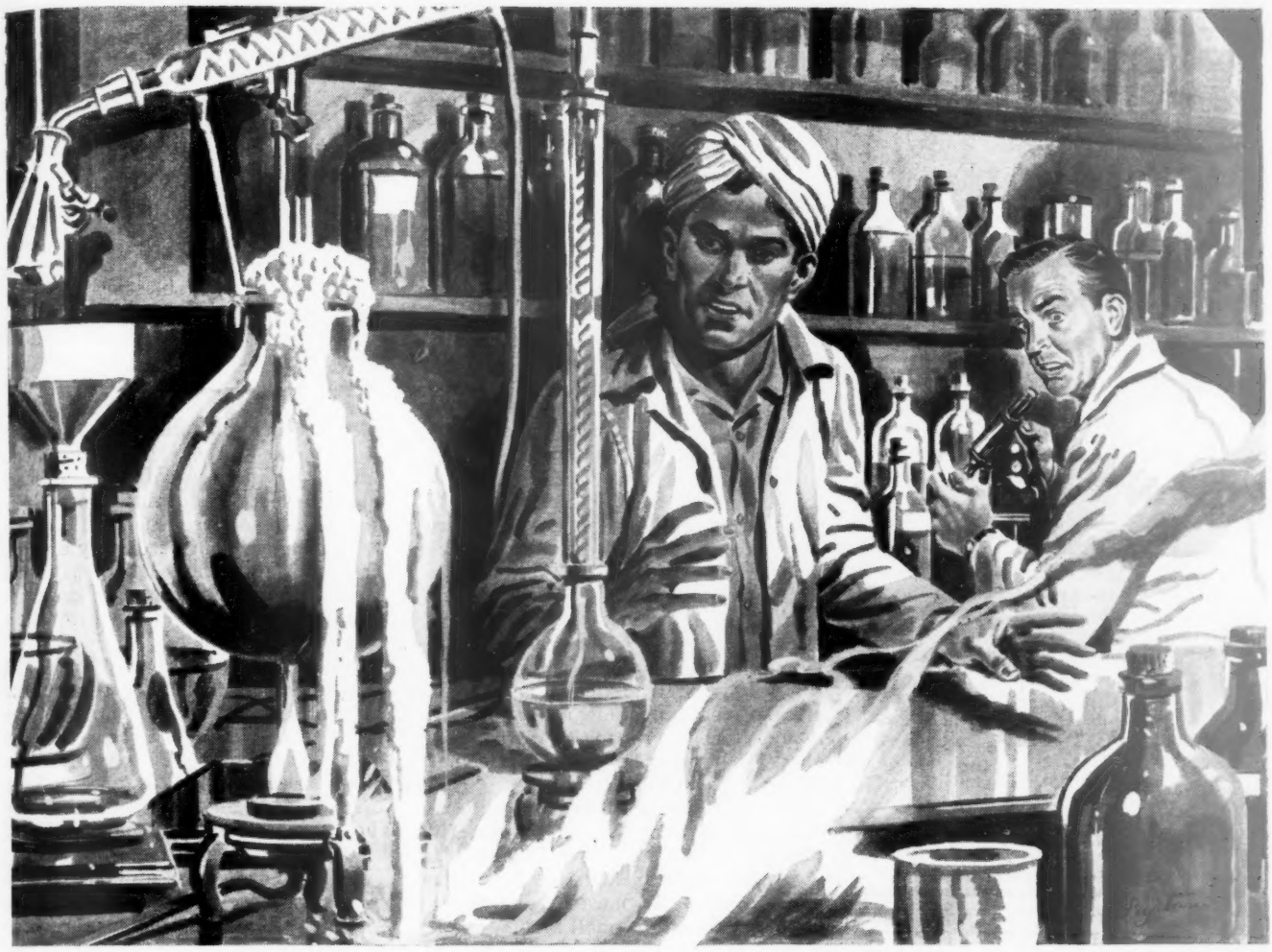
Just as packaged compressor plants lend themselves to oil and gas production, they have proved their value in other fields as well. They have been installed in industries for compressing large volumes of compressed air or for refrigeration. Installations have varied from small single units to multi-unit banks of the large 550 hp units.

In any installation, approximately the same components are required for refrigeration or compressing air as are required for compressing gas. In industries as well as in remote gas fields, the economies of complete packaging have effected material savings in installation and operation.

We have discussed the economies of complete packaging. Now let's take a look at the reasons why packaging saves on both installation costs and operational costs.

Although there are a number of standard size packaged compressor plants on the market, the standardization is only on the power end. The compression end is a custom designed job. Each one must be engineered specifically for the job it has to do.

This does not mean that we would take one suction and one discharge pressure and design a plant for this job alone. It means that we would take a look into the future and determine what the conditions will be as the years progress. As an example, let's assume that we are asked to design a packaged compressor plant to pick up gas at 800 psig and discharge at 1000 psig. After some questioning we determine that the 800 psig suction pressure will in a few years time have dropped to 400 psig. This means that we must design all of the compressor cylinders, scrubbers, manifolds, etc., large enough to handle the low pressure, but heavy enough to handle the high pressure. We must also consider that when the pressure reaches 400



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psig the customer will not want to abandon the well, but will want to two-stage the machine in order that he can follow the suction pressure on down. By knowing in advance, we can design so that instead of having to replace all of his cylinders, scrubbers, etc., it will only be necessary to change one of them or at the most, two.

Another problem we often face is that of designing a plant to pick up gas at 250 psig and discharge at 550 psig. After some questioning it is discovered that these pressures are weighted averages. The intake pressure will actually range from 200 to 300 psig and the discharge pressure will vary from 500 to 600 psig. Also, the plant may be called upon to operate through this entire range of pressures within a 24 hour period. A compressor plant designed and built for the fixed average conditions will perform in an unsatisfactory manner when actually on the job. The compressor cylinders would have the engine either underloaded or heavily overloaded, the scrubber would be undersized for the low pressure and the shell too thin for the high pressure. The safety relief valve would be improperly set, the manifold piping too small. Although it could be made to operate, this operation would be neither safe nor efficient.

For that reason it requires experienced process engineering to properly size the cylinders, piping, manifolds, scrubbers and coils throughout the plant. And all this must be planned to fit compactly into a small area.

In their designs the engineers use standard components wherever possible to hold down initial cost, as well as cost for any modification that may be made later. By means of centralized purchasing, too, the manufacturer can take advantage of quantity buying. This also assures the manufacturing department of having enough necessary parts when needed without any waiting for the missing part.

In any compressor station there are several hundred separate components. These must be designed or selected to go together into a coordinated unit. Each part must be requisitioned, warehoused, inspected and finally built into the plant.

It is easy to see why a great deal of money, and time as well, can be saved by performing all the manufacturing operations, from engineering to final inspection, in one central location.

And you can readily visualize the expense of assembling all these parts, fitting them together in the field with field labor without the manufacturing facilities of a modern factory.

In the matter of foundations alone, which for the conventional stationary plant require careful designing, expensive forms and large masses of concrete, the packaged plant needs only a simple concrete slab at the location. Its rugged steel base is engineered to carry the load and is formed to the base of the compressor.

When the plant arrives at location, it is skidded onto the slab, grouted in and bolted. Then, only three connections are required to put it on stream — suction and discharge lines and fuel gas line. When these are hooked up you know that you are ready to go on stream. You don't have to worry about some small missing part delaying you for days.

Usually, one of these plants requires only a light shelter to keep off the rain, although some installations are completely enclosed.

In operation, as well as in installation, there are many factors that save money. We have just mentioned one in particular — the changing of a one-stage unit to a two-stage unit. Here, because provision is made in the design, the additional equipment may be added when required without expensive rebuilding.

Another great saving results from the fact that packaged plants require less attention. In fact it has been found by one large producer that those units that have regular attendants require more maintenance than those that are left alone. They can be left alone — except for routine checks — because of the automatic controls that act as watch dogs, 24 hours a day. Also, automatic controls do not tinker with the mechanism. If any irregularity in operation should develop, they immediately shut down the engine and wait for an experienced service man.

In some types of service, compressors may not be needed after a period of years. An example of this is depletion of gas wells. Oftentimes it is then desirable to move the plant to a new location where compression is needed. Here again, packaged plants save the producer. For almost all of the plant is salvageable. About the only thing which must be abandoned is the concrete slab on which the plant rests.

The entire unit may be moved intact to a new site, just as it was originally

TABLE 1. Cost estimate 3300 hp installation of packaged compressor plant.

Qty.	Item	Material	Labor	Total
6	550 hp packaged compressors	$483,000	.....	$483,000
	Freight	3,420	.....	3,420
	Handling charge	.....	.....	2,100
	Foundation and floor	3,700	7,350	11,050
	Grouting	.....	540	540
	Building	7,510	1,600	9,110
	Electrical	860	700	1,560
	Paint	100	600	700
	Miscellaneous piping	3,120	2,000	5,120
	Gas measuring and regulation equipment	3,000	1,800	4,800
	Miscellaneous labor-erection	.....	5,070	5,070
	Headers:			
	Suction	3,549	2,350	5,899
	Discharge	8,452	11,412	19,862
	Fencing	1,440	540	1,980
	Land (4 acres)	5,000	.....	5,000
	Grading and drainage	2,600	.....	2,600
	Engineering and design	.....	1,250	1,250
	Office building	1,200	800	2,000
	Furniture-office building	1,300	200	1,500
	Sub-totals (Less compressor costs)	45,249	38,312	
	Purchase costs & insurance	2,262	6,130	8,392
	Contractor's fee: Tools Overhead Supervision Profit			
	Supplies	.....	6,513	6,513
	Adding compressor costs	483,000	.....	.....
	Grand total	$530,511	$50,955	$581,466
	Based on 3300 hp — Cost per hp			$176.00

transported from the factory and put on stream again after making the same three simple connections required at the first location.

In the preceding part of this paper we have attempted to show how, by standardization, quantity purchasing and factory manufacturing, the cost of the packaged compressor plant can be held to a minimum.

Table 1 tabulates the actual costs, completely installed, of a 3300 hp plant, comprised of six 550 hp compressors. This table shows that the completely installed cost is $176, per horsepower. To those of you who have had experience with the permanent type installation of compressor stations, this will no doubt seem to be a very low figure, for you would normally expect this cost to run from $250 to $300 per horsepower. The figures here speak for themselves, however, and are taken from an actual bid. I would like to point out, however, that to get these low figures it is absolutely imperative that the plant be completely designed and every piece be fabricated in the plant or factory and installed on the base before shipment to the job. For every item of work that has to be done in the field, the costs go up.

We have spoken earlier of the low operational cost to be expected from the packaged-type installation. Table 2 shows a comparison between an installation of packaged compressor plants and a permanent type station. Column 1 shows the actual operating and maintenance costs of a 1200 hp packaged compressor plant consisting of four 300 hp units for a period of 11 months. You will note that the operating cost per brake horsepower per year is $13.50 and that maintenance cost per brake

TABLE 2. Comparison—operating and maintenance costs. Actual cost records from one of the largest gas companies in the U. S. A.

	*No. 1	*No. 2
Brake horsepower hours operated	2,223,511	22,598,793
Operating labor cost	$ 7,393	$36,699
Fuel cost at 5 cents per mcf	2,523	12,655
Lube oil at 60 cents per gal	2,393	4,127
Other supplies	439	418
Automotive	8	446
Other expenses	587	2,702
Electric power	279	7,182
Overhead expense	1,230	6,612
Sub-total	$14,852	$70,841
Operating cost per brake horsepower per year	$13.50	$17.70
Maintenance:		
Labor	$ 792	$5,445
Material and supplies	1,385	3,505
Automotive	.....	401
Other expenses	475	1,548
Overhead	110	694
Total	$17,614	$82,434
Maintenance cost per horsepower per year	$2.50	$2.90
Total operating and maintenance cost per brake hp per year	$16.00	$20.60

*No. 1 is a 1200 horsepower packaged type compressor station semi-manned. Operating period is eleven (11) months. Brake horsepower hours operated indicate actual brake horsepower hours compressing gas only. The compressors are equipped with automatic unloaders and float on the line at half speed completely unloaded, until the line pressure falls below a predetermined point.

No. 2 is a 4000 horsepower fully manned station using two men per shift with relief crew (approx. fifteen men). Operating period twelve (12) months.

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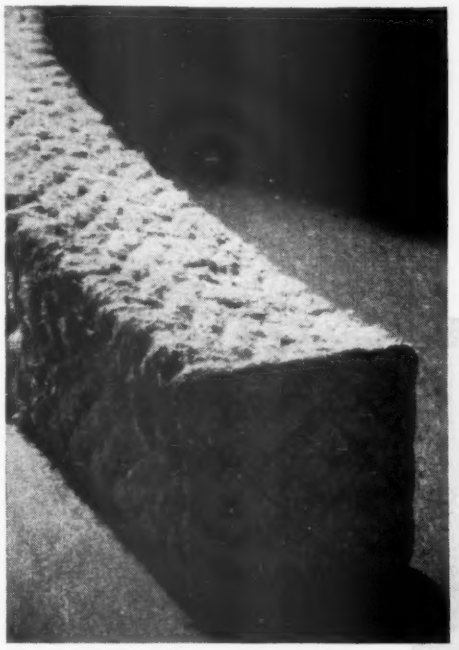

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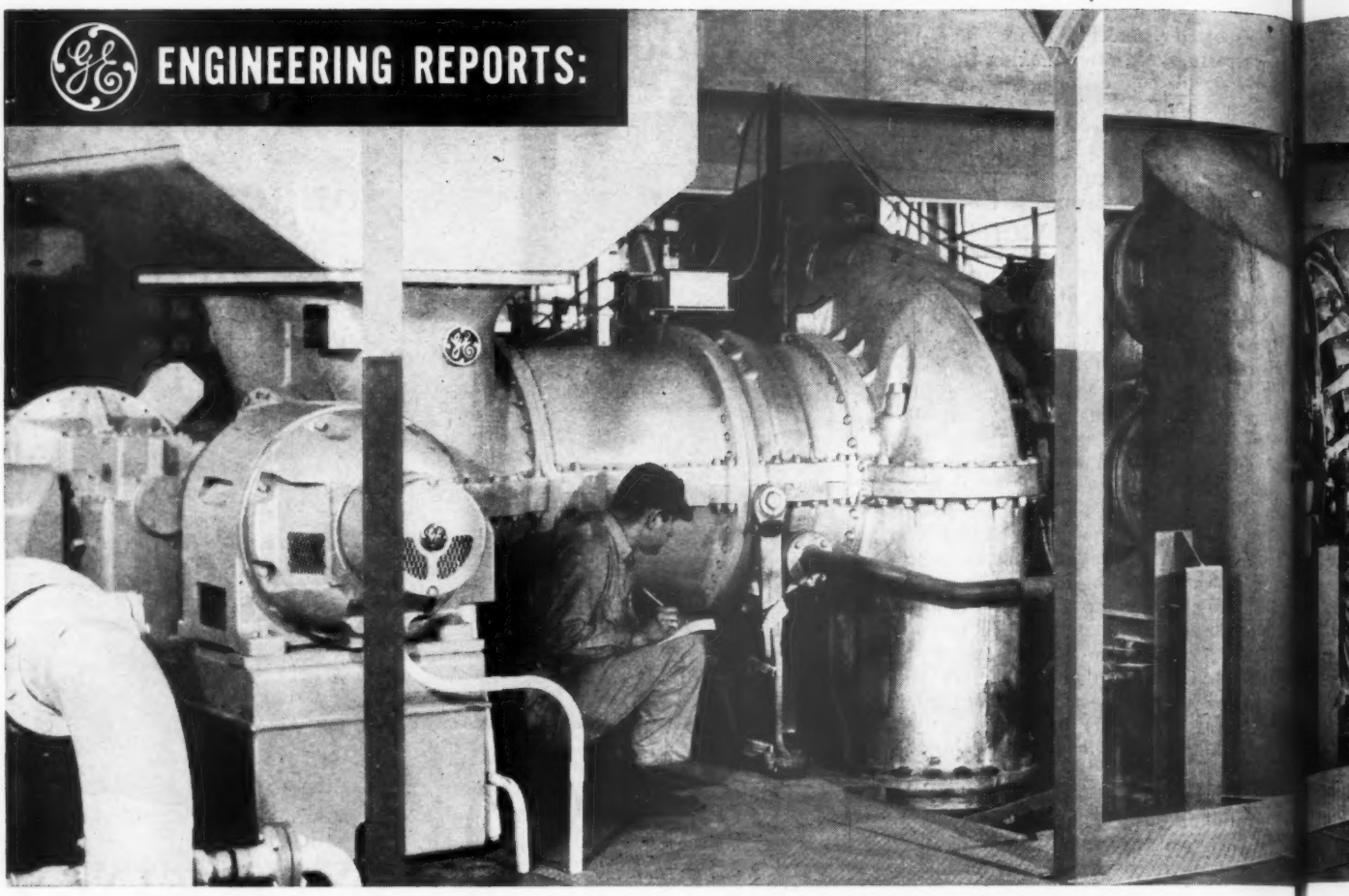
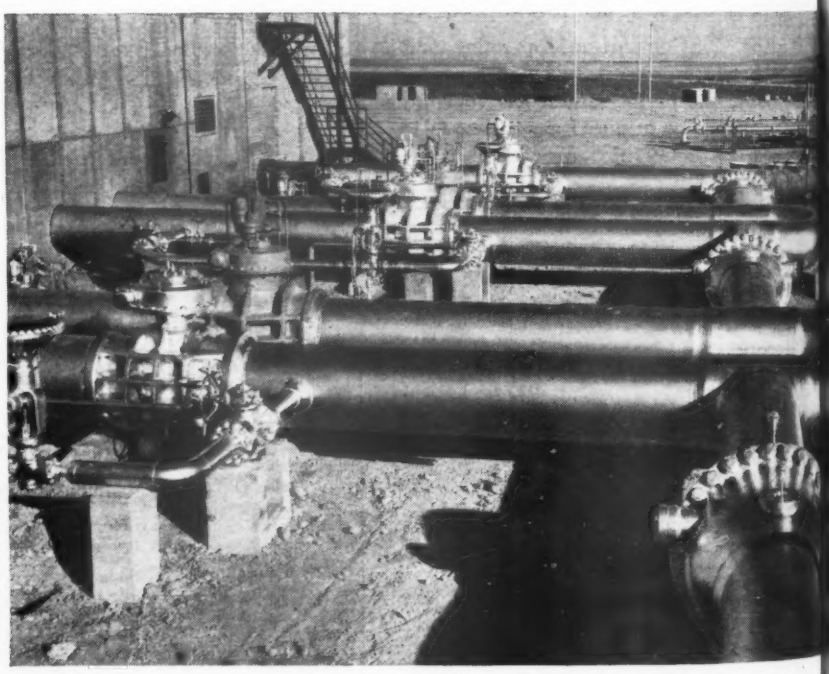


This G-E gas turbine is the first of 28 installed for gas pipeline pumping by the El Paso Natural Gas Co.

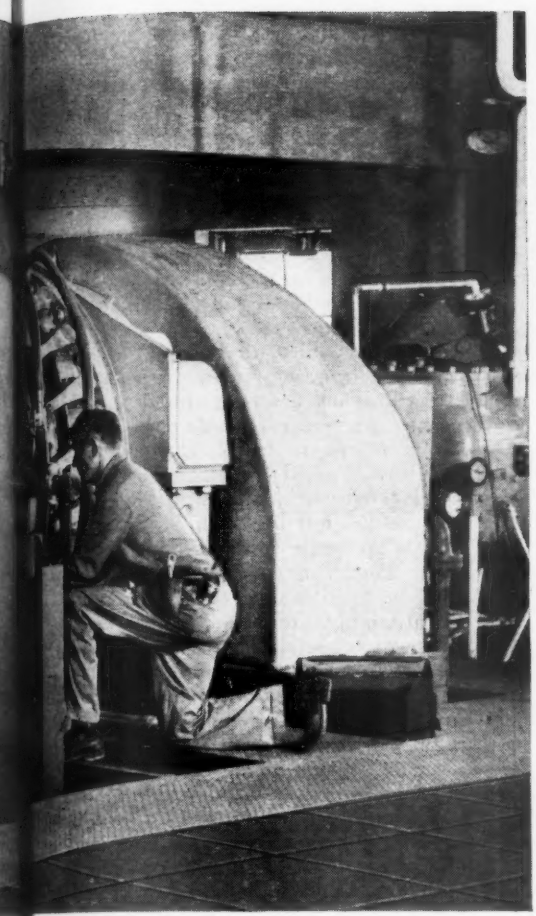
El Paso reports performance of G-E

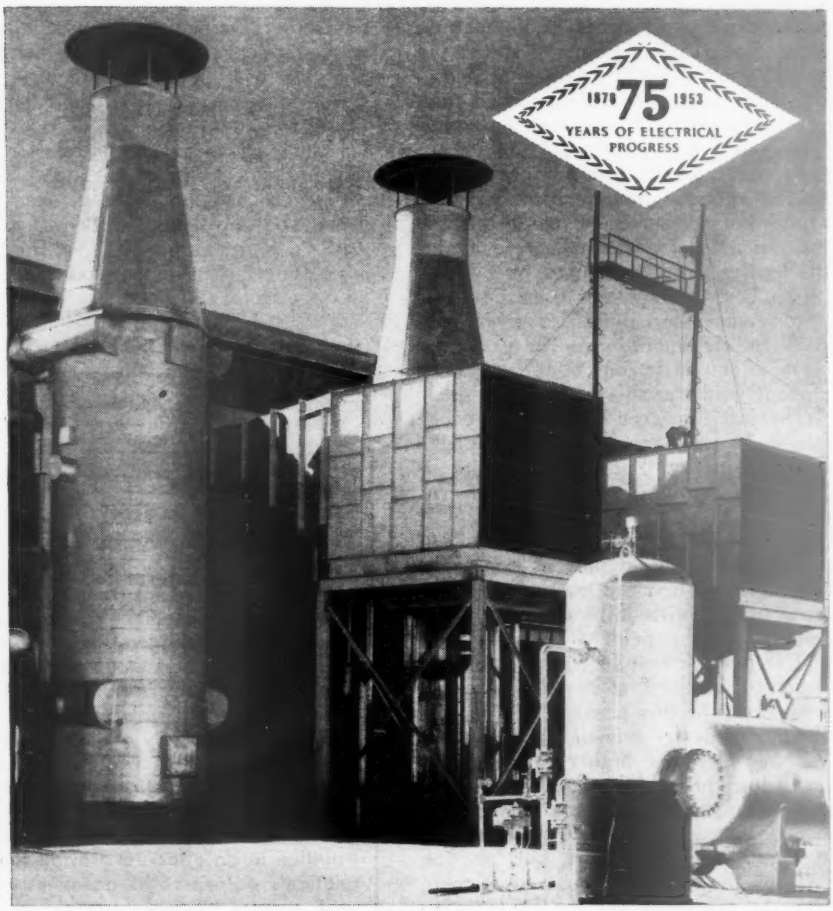
NO OUTSIDE POWER IS NEEDED—panel above provides control for station auxiliaries. Auxiliary generator, driven by the turbine, provides all a-c power while turbine is operating.



MAIN GAS PIPING is simplified by use of gas turbine-driven centrifugal compressors. The suction and discharge valves, purging and pressurizing valves are all controlled automatically on start. The G-E gas turbine is automatically loaded, and the station discharge pressure is maintained automatically.

XUM





HIGHER EFFICIENCY—regenerators "recapture" waste heat, enable turbines to pump with efficiencies comparable to other types of power plants.

gas turbines exceeds expectations

Records of first 15 combustion gas turbines used for pipeline pumping show they start fast, save fuel, simplify operation

So far, El Paso Natural Gas Company has put 15 General Electric combustion gas turbines into operation on their cross-country gas line. Performance has been carefully watched. El Paso has found:

1. **Stations start in 19 minutes—automatically.** Station batteries and pipeline pressures do it all.
2. **Five-man crews can operate stations.** The simple construction of the turbines means reliable performance, easy operation, less maintenance.
3. **Operation proves turbine flexibility.** During nine months of operation under fluctuating conditions, the turbine at Cornudas Station performed with even greater flexibility than had been predicted.
4. **Personnel training system is highly satisfactory.** Key El Paso personnel were sent to the G-E gas turbine plant for intensified training. They in turn trained regular operating staffs. All new positions have been filled by company personnel.

G-E system engineers will be working closely with El Paso engineers during installation of the 13 combustion gas turbines still to go on the line. Your G-E Apparatus Sales Representative can tell you more about their services—and about the G-E gas turbine. Ask him also, to arrange for a showing of the new full-color film, "The El Paso Story," or write to General Electric Company, Schenectady 5, New York. 661-41

Combustion Gas Turbines for the Gas Pipeline Industry—Backed by 45 years of Turbine Leadership

GENERAL ELECTRIC

horsepower per year is $2.50, making a total of $16.00. Column 2 shows the actual operating and maintenance costs of a 4000 hp permanently installed compressor station and covers an operating period of twelve months. The operating costs per brake horsepower per year is $17.70 and the maintenance cost per brake horsepower per year is $2.90, making a total of $20.60. Here again, the figures speak for themselves. Needless to say, this operator uses the packaged compressor plant wherever possible in his operations. These figures serve to emphasize one of the most important points of this discussion.

The low first cost should not be obtained by sacrificing either completeness or quality. For any given job a definite amount of equipment is required.

It is more economical to purchase this equipment as a part of the packaged compressor plant than to purchase these parts individually and have them installed in the field.

It is possible to effect a considerable reduction in the first cost by lowering the quality of this equipment. Any reduction made by this means, however, will be offset by higher maintenance costs and these higher costs are with you as long as you operate the equipment. Along with the expense of replacing parts that have worn out, do not overlook the fact that you are *not compressing gas while the mechanic is at work.* The cost of lost production does not show in an operating and maintenance statement, but in the writer's opinion, it should be included.

The manufacturers of ball and roller bearings have established a life factor for their product. The purchaser can select a bearing for his particular application with reasonable assurance that it will have a definite operating life. While compressors are not sold on this basis, the fact remains that the same limiting factors are there.

With high speed, automotive type engines driving light weight, intermittent duty, air compressors that have been adapted to gas service, some saving in first cost can be shown. Maintenance and operating cost, as well as down time, will be increased over that of the heavy duty equipment if this type of unit is subjected to continuous 24 hour per day operation. The reason is quite plain, the components were neither designed nor built for this duty. When used in the service for which they were designed, both the engine and the compressor will give excellent performance. Most jobs of gas compression in the oil and gas fields do not fall within this classification.

The heavy duty, direct connected, gas engine driven compressor, of the sizes used in packaged compressor plants, can be expected to operate continuously for from twenty to thirty years. With proper preventive maintenance, they can be expected to operate 24 hours per day for the full life span.

It is far better to be able to shut the plant down at your convenience for periodic maintenance, than to be called out at midnight to make a major repair.

Now, to conclude this discussion let's summarize the main points that have been covered in detail. A packaged compressor plant is a complete plant — it is fully assembled at the factory — it is compact enough to be transported on oil field trucks. It is adaptable to any use where gas or air must be compressed. Whether used as single units or in large banks of many units, it has been found to reduce the cost of installation and to save on maintenance expense. ★ ★ ★

Gasoline Studied In Research Project

Mr. Average Motorist may not realize it, but every gallon of modern gasoline contains from 3500 to 5000 different chemical compounds made up of hydrogen and carbon. Each of these compounds has a "personality" all its own. A research project to make, purify and engine-test as many of these compounds as possible was begun 15 years ago by American Petroleum Institute. Experimental fuels costing over $1300 a gallon are being studied in an effort to provide the nation's motorists with gasolines of still greater efficiency.

PETROLEUM ELECTRIC Power Association officers and board of directors named recently are: Seated, Thomas E. Graham, Oklahoma Gas and Electric; Ned W. Beaudreau, Central Power and Light; Fred B. Clark, Arkansas Power and Light, secretary-treasurer; James E. Moody, Southwestern Gas and Electric, president, and W. L. Pearson, Southwestern Public Service, vice president. Standing, Kirby Dawkins, West Texas Utilities, board of directors; Fred Woerner, Texas Electric Service; Willis Frohock, Kansas City Power and Light; Harvey Cherry, Houston Lighting and Power; V. H. Ohrman, Texas Power and Light, and Tom D. Hoskins, Louisiana Power and Light. Not present, Henry C. LeVois, Gulf States Utilities Company.

Output Cut in Most Oil Producing States

Texas is producing 140,531 bbl per day less this month than last, due to a cut in allowables made by the Railroad Commission. This is the third month that output has dropped.

New quota is 2,803,528 bbl daily, 360,374 bbl below the level reached late in July, before the maximum production began dropping.

Texas Independent Producers and Royalty Owners Association answered the cut order with charges that importers are bringing in more and more oil while domestic production is being reduced in an attempt to bring down high inventories.

Although other states have been having their troubles, too, with lowered oil output, Louisiana, third largest oil producing state, increased its allowable for this month.

A 20 per cent cutback in New Mexico's maximum permissible flow for this month has been recommended by the state's oil conservation commission engineer. Elvis Utz, the engineer, recommended a basic daily output of 213,787 bbl in addition to 2400 bbl of northwest New Mexico production and 10,000 bbl allowed for new wells. October's output was 215,785 bbl.

In Kansas oil men observed a 10-day ban on oil production last month at the direction of the Kansas Corporation Commission. More than 25,000 producing wells were ordered shut down after above-ground storage reached what the commission termed "excessive." Only wells that produced during the shutdown were those flowing from waterflooding operations.

At the same time Oklahoma was feeling the effects of a cutback in allowables. October's production was 30 per cent that of August with November's expected to be approximately the same as the month before.

PEPA Elects Officers At Annual Convention

The Petroleum Electric Power Association elected officers and directors for the year 1954 at its annual convention held in Kansas City recently. New president is James E. Moody, Southwestern Gas and Electric Company; W. L. Pearson, Southwestern Public Service, vice president, and Fred B. Clark, Arkansas Power and Light, secretary-treasurer.

This is the silver anniversary of this organization, which was formed in Kansas City in 1926 to promote the use of purchased electric power by the petroleum industry.

Continental Wins Top Award on Annual Report

In the final ratings of the independent board of judges in the thirteenth survey of 5000 annual reports, conducted by "Financial World," Continental Oil Company was judged as having the best annual report of the petroleum industry for the first time. The bronze "Oscar of Industry" trophy was presented to L. F. McCollum, president of the company, at the Annual Awards Banquet in the Grand Ballroom of the Hotel Statler, New York, on October 26, 1953.

In this industrial classification Gulf Oil Corporation was runner-up for top honors, while Creole Petroleum Corporation placed third.

New Service Announced

Petroleum Information has announced formation of a new oil publication.

Called "Oil In The Rockies" the new service combines a map of the Rocky Mountain region on which progress of all exploratory drilling is noted, with a concise review of each month's activities in all phases of the oil industry in the region.

Oil In The Rockies will be issued monthly as an analysis and forecast of activities in exploration, drilling, refining, pipelining. It will also present reviews and summaries of outstanding regional operations.

PART OF a $5,000,000 natural gasoline plant being built in the Pledger field, near West Columbia, Texas, for Southern Production and Humble Oil and Refining Companies. Stearns-Rogers Manufacturing Company is building the plant. Unit is 154 ft OD by 124 ft long, and estimated weight is 205,000 lb. Railroads handling the shipment have scheduled it to travel only in daylight, at no more than 25 miles per hour. All railroad clearances between the Stearns-Rogers shop and plant site were carefully checked and special routing arranged so that shipment will not travel on outside of curve while another train is on adjoining track.

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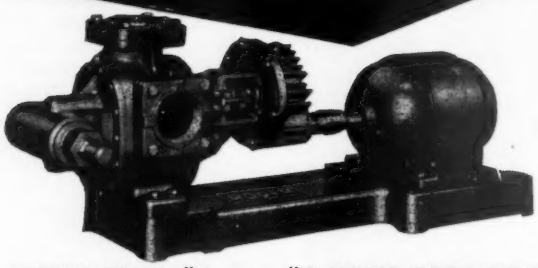
2 NEW MODELS IN ROPER 3600 SERIES



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Wanted soon: Used natural gasoline plant to extract natural gasoline, butane and propane to handle 4 to 8 million C. F. daily wet gas. Goodalls, Ogallala, Nebr.

FOR SALE — ELI Model M-6 portable drilling rig on GMC Truck. Ideal for water wells. Will consider good spudder as trade. Vaughn & Taylor Construction Co., Inc., 2103 North Grant, Odessa, Texas, Phone 7-2091.

NEWS

PAD May Be Abolished

The Petroleum Administration for Defense, already cut to the bone in personnel, may be in for final abolition in a few months, and some officials believe it may expire January 1. H. A. Stewart, acting deputy administrator of PAD has asked Walter S. Hallanan, National Petroleum Council, to name a committee to study organization of a peacetime setup to deal with oil and gas problems in case PAD is done away with. This Hallanan has done, and has named B. Brewster Jennings, president, Socony-Vacuum Oil, as chairman.

Stewart in a letter to Hallanan recommended that PAD be liquidated as soon as it has completed its "emergency defense responsibilities" suggesting that any long range problems in the oil and gas industries remaining after the abolition of PAD could be handled by a "normal peacetime organization," such as the Interior Department's oil and gas division.

Alaska Governor Asks Freeing of Point Barrow

Governor Heintzleman of Alaska has been in Washington recently asking release of the Point Barrow Naval Petroleum Reserve for oil and gas exploration by private industry now that the Navy is abandoning its exploration work there.

Heintzleman also asked the Interior Department to release some 37,000 sq miles on the Arctic slopes north of the Brooks Range, for private exploration. This area borders the Umiat region where the Navy drilled a number of test wells.

Sun Dedicates Building

Sun Oil Company dedicated a new office building at Smiths Bluff, near Beaumont, Texas, as part of its Oil Progress Week celebration recently.

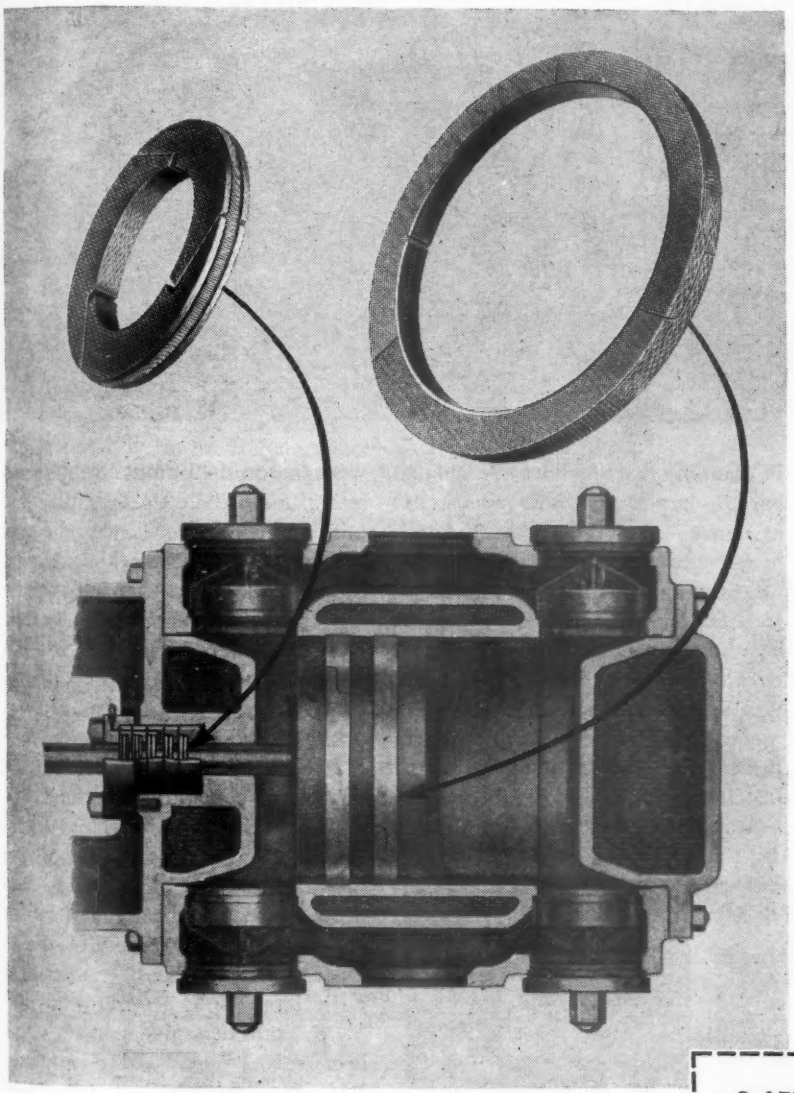
The one-story, air-conditioned masonry building will house personnel in charge of Sun's blending and packaging plant, laboratory, warehouse, package dock, and the distribution of bulk and packaged lubricating oils, waxes and specialties.

Containing office space for A. S. Johnson, manager; H. W. Hillis, assistant manager John W. Shaw, foreman; and the clerical force required for the operation, the building covers approximately 1200 sq ft.

New Tide Water Thrift Plan

Stockholders of Tide Water Associated Oil Company have aproved adoption of a thrift plan for employees of the company and certain subsidiaries, according to an announcement released by D. T. Staples, Tide Water Associated president. The plan provides that participating employees may elect to save from their monthly compensation an amount not exceeding approximately 5 per cent of their base compensation. The company will contribute an amount equal to 50 per cent of the savings allotment of each participating employee.

Which of these laminated phenolic (bakelite) packing and piston ring materials is best for you?



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COOKROC bakelite packing and piston rings were especially developed to meet the need for rings that would stand up under the action of corrosion, dirt and faulty lubrication. They're made of a strong tough material whose fibers act as wicks in retaining lube oil. Their unusual combination of properties – such as low coefficient of friction, high strength and chemical resistance, make them ideal for compressors handling corrosive gases and liquids. They're made in three grades, in a range of sizes and styles to fit any standard compressor.

STANDARD COOKROC is fabricated from sheets of light-weight cotton fabric bonded together with a chemical resistant phenolic resin. It has the following properties:

Flexural strength	15,500 psi
Tensile strength	8,200 psi
Compressive strength	37,000 psi
Shear strength	14,500 psi
Specific gravity	1.36 psi
Coeff. of thermal expansion	2.2×10^{-5} in/in/°C
Normal continuous operating range	275°F

GRAPHITIZED COOKROC has the same properties and temperature range as Standard except that finely powdered graphite is added to improve its wearing properties. It's generally used where lubrication is at a minimum.

HIGH-TEMP ASBESTOS WOVEN COOKROC has approximately the same physical properties as Standard except that it is capable of withstanding much higher temperatures.

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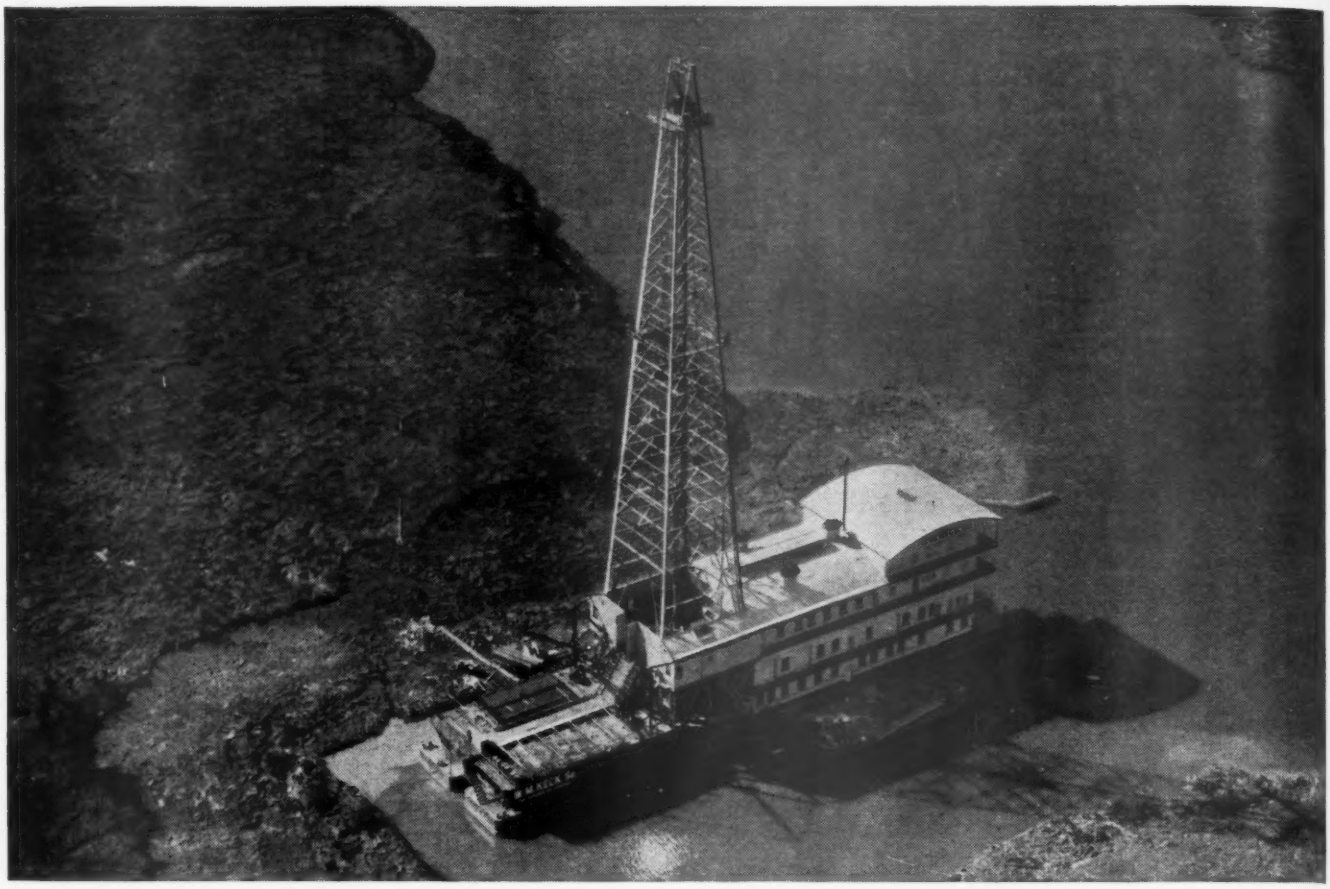
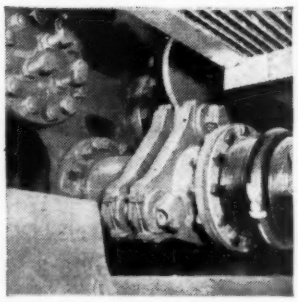


U.S. Rubber keeps the "shakes" away from this barge

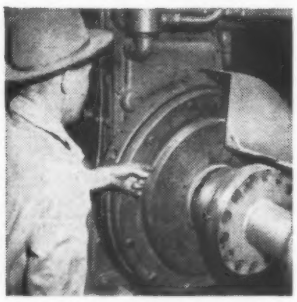
In planning this off-shore oil-drilling barge – largest and most modern in existence – the designers *had to* make sure that her many drilling and pumping engines would not subject her to destructive vibration. They consulted United States Rubber Company engineers. The answer was quick and effective. Rubber mountings were installed to cushion the engines. Rubber couplings were installed to protect drive shafts from vibration. U.S. Expansion Joints were put on the pumps in the circulating line to take up vibration and misalignment. Ever since her first day on the job, the barge has had no case of "the shakes." Men wonder how they ever lived through it before. Now the owners are pleased, and off-duty crew members can relax in restful comfort. Their quarters are *free of vibration* and *free of noise*.

U.S. Mountings are also used on engine generators, welding machines, and air compressors. Whenever you have a problem involving the transmission of vibration and noise, or require mechanical rubber goods, always call on any of our 25 District Sales Offices, each staffed with engineers. Remember that "U.S." products give you *economy* because they are *quality* products. Write to address below.

This U. S. Rubber Mounting is one of four installed under each of the engines that operate the draw works of the drilling rig.



U. S. Expansion Joint is at the suction end of every mud pump to take up vibration and misalignment.



This U. S. Rubber Coupling, installed on the power take-off end of the large engines that operate the draw works, stops the transmission of vibration. This coupling is widely used in the oil fields.

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New Provisions May Hamper Sale of Rubber Facilities

Sale of synthetic rubber plants owned by the government has been hampered by recent legislation passed in Congress. Approval of the sale was made by President Eisenhower August 7, when he recommended a three-man commission to handle negotiations. To date only two of the men have been named by the President and it has not been announced who, nor when, the third man will be named.

The first bill introduced into the House provided for 90 days bidding period and 4 months negotiation period, but the Senate has changed the bill to a 6 months' bidding period and the latter provision to 7 months. Also the Senate added an amendment that provides that any single item in the sale could be rejected by Congress at the last minute, however, this amendment was changed later to give buyers the right to withdraw their offers should Congress refuse to sell any facility.

A further amendment provides that the attorney general give a written opinion to the effect that provisions of sale of the synthetic rubber plants are not inconsistent with the antitrust laws. Previously the Department of Justice had expressed a verbal opinion that the sale was within the bounds of antitrust limitations. Some observers think the attorney general might not make such a written statement as it might possibly be used against him in further antitrust actions. Should he refuse, no disposal program could be carried out.

Oil Imports Up in U. S.

Total crude imports of oil into the United states were back up to the 1,000,000-bbl per day mark for the week ending October 10, according to a report by the American Petroleum Institute.

Import total was 1,020,200 bbl per day and 1,261,600 bbl per day the week before. For the same week a year ago the total was 905,300 bbl per day.

Week ended	Crude oil	Residual fuel oil	Distillate fuel oil asphalt, etc.	U. S. total
September 12..	598,200	342,600	5,000	945,900
September 19..	698,700	347,500	42,000	1,088,200
September 26..	489,800	293,600	20,300	863,000
October 3.....	720,100	369,900	45,000	1,261,600
October 10....	650,400	209,700	23,000	1,020,200

Liquid Evaporation Study Will Be Made by API

A new committee to study losses of petroleum liquids by evaporation has been appointed by President Frank M. Porter, of the American Petroleum Institute. J. H. McClintock, of Esso Standard Oil Company, New York, was named chairman.

The group is to be known formally as the Committee on Evaporation Loss. The specific scope of its activities will be "the development of factors governing the evaporation loss of petroleum liquids for use in the solution of operating problems."

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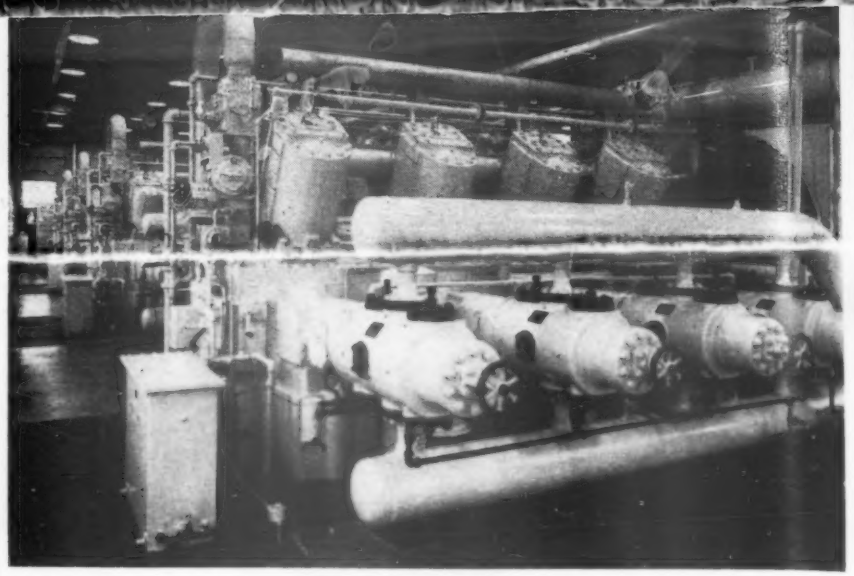


BANK of four 440-hp packaged compressor plants boosts field gas from a gathering system up to pipe line pressures. Each unit is a complete plant, assembled at factory on its own specially formed steel base.

will allow increased oil production if this gas can be saved. If there is a gas line available nearby, it can be compressed to line pressure and sold. Otherwise, it can be pumped back into the reservoir to maintain pressure and the flowing life of the field prolonged. Increased allowables mean increased income for the oil producer and the packaged compressor plant under these circumstances will usually pay for itself in a very short length of time.

But the packaged plant has found its greatest use so far in the production of gas. As gas gathering systems have reached farther and farther into new fields, it has become necessary to maintain reasonably high line pressures, and, at the same time keep gas flowing into these lines from all wells in the fields.

When field pressures begin to fall, some wells will not flow into the gathering lines at all. Others will have their flow sharply reduced. Usually these wells are fairly well grouped so that two or three or even many more may be tied into one field compressor and the gas compressed to pipe line pressure.

This is far more economical than lowering line pressures in the field and installing compressors in the gasoline plant. For, in this event all of the gas from the field must be compressed, while only a small per cent — say 10 per cent — may actually require it.

If a compressor were centrally situated at the plant to handle an entire field, it would also be necessary to install a new field gathering system. For example, a line designed to carry a given volume of gas at 1400 or 1500 psi would handle a far smaller volume at 200 or 300 psi.

There would also be a saving in the compressor installation itself by using smaller field compressors near the wells. Less overall horsepower would be required to deplete the field, because as the first wells requiring compression are depleted, the packaged compressor plants can be moved to other locations in the same field and reused. I believe that this one feature would result in a saving estimated conservatively at 25 per cent and possibly more.

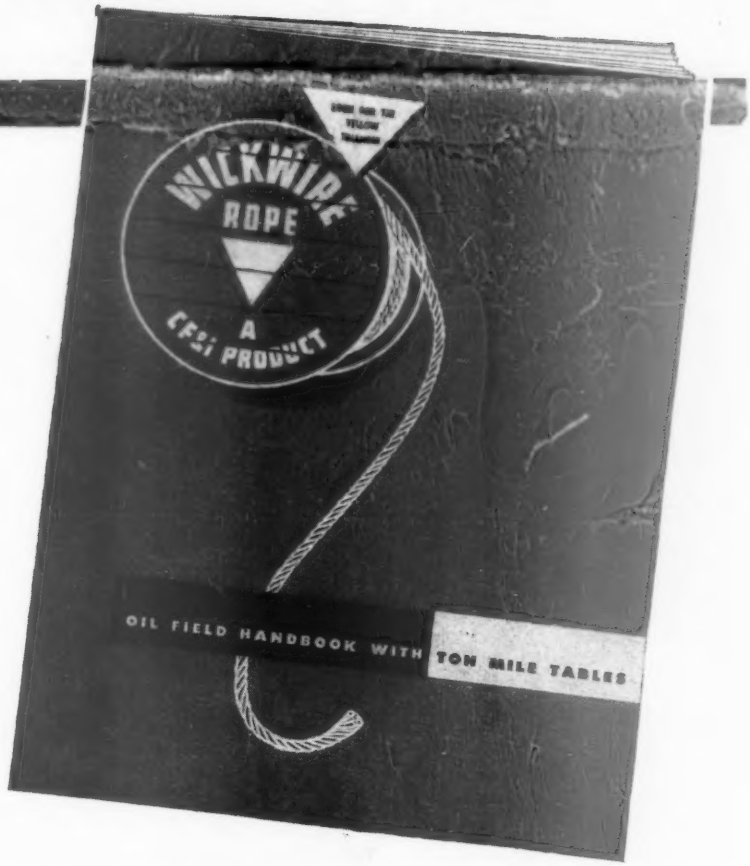
Another economy of the packaged compressor plant in gas boosting is its ability to handle varying load conditions with very little change. For example, the plant is usually a single-stage unit when installed. That is, all of its compressor cylinders have the same suction pressures and the same discharge pressures.

These cylinders are sized to permit operation at a suction pressure equal to or slightly less than the discharge pressure, but large enough to permit operation until the suction pressure has declined to such a point that single stage compression can no longer be used efficiently.

When this time arrives the change to two-stage compression can be made by adding one, or at the most, two new cylinders for the first stage, installing a gas intercooling coil on the radiator, and mounting a second stage scrubber. The cost of such a changeover is held to a minimum, because in the basic design, provision had been made to accommodate this equipment. With the exception of the new compression cylinders, the cost will be no greater than if it had originally been purchased as a two-stage plant.

In the conservation of natural gas, the packaged compressor plant has played a large part. Not too many years ago gas was considered a necessary evil in the production of oil, to be separated from the crude oil the best way possible and disposed of by burning.

ROPE



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For some of it had a bad habit of settling in low places where it was likely to explode when some unsuspecting person struck a match. Now we know that the part that settled out was the butane or propane fraction that has a specific gravity greater than air.

During this time, especially in isolated areas, gas wells were plugged.

Later, the gasoline plant was developed to recover from wet gas the natural gasoline, or, as it is generally called, casinghead gasoline. Gathering lines were laid into fields where the GPM content was relatively high. Separator gas was brought to the gasoline plant and stripped. The residue gas was returned to the leases for fuel or any other local uses for which gas might be required.

Usually, producers required only a very small portion of this residue gas for such purposes, so the gasoline plant flared what was left. The producer was paid on the GPM only.

Today, with the packaged compressor plant in use, this residue gas may be utilized for gas lift, repressuring, or for delivery into the gathering system of a gas transmission line.

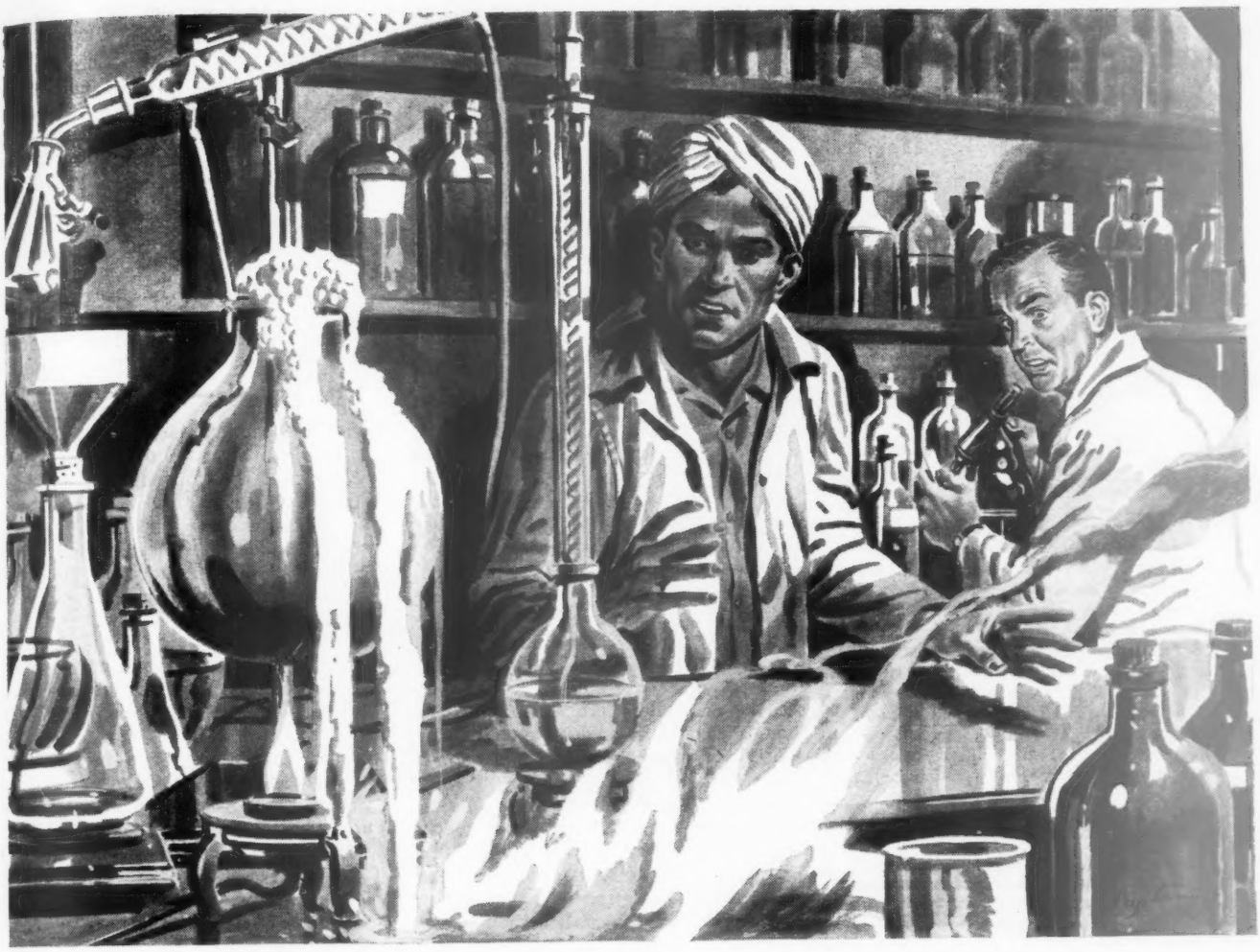
Just as packaged compressor plants lend themselves to oil and gas production, they have proved their value in other fields as well. They have been installed in industries for compressing large volumes of compressed air or for refrigeration. Installations have varied from small single units to multi-unit banks of the large 550 hp units.

In any installation, approximately the same components are required for refrigeration or compressing air as are required for compressing gas. In industries as well as in remote gas fields, the economies of complete packaging have effected material savings in installation and operation.

We have discussed the economies of complete packaging. Now let's take a look at the reasons why packaging saves on both installation costs and operational costs.

Although there are a number of standard size packaged compressor plants on the market, the standardization is only on the power end. The compression end is a custom designed job. Each one must be engineered specifically for the job it has to do.

This does not mean that we would take one suction and one discharge pressure and design a plant for this job alone. It means that we would take a look into the future and determine what the conditions will be as the years progress. As an example, let's assume that we are asked to design a packaged compressor plant to pick up gas at 800 psig and discharge at 1000 psig. After some questioning we determine that the 800 psig suction pressure will in a few years time have dropped to 400 psig. This means that we must design all of the compressor cylinders, scrubbers, manifolds, etc., large enough to handle the low pressure, but heavy enough to handle the high pressure. We must also consider that when the pressure reaches 400



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psig the customer will not want to abandon the well, but will want to two-stage the machine in order that he can follow the suction pressure on down. By knowing in advance, we can design so that instead of having to replace all of his cylinders, scrubbers, etc., it will only be necessary to change one of them or at the most, two.

Another problem we often face is that of designing a plant to pick up gas at 250 psig and discharge at 550 psig. After some questioning it is discovered that these pressures are weighted averages. The intake pressure will actually range from 200 to 300 psig and the discharge pressure will vary from 500 to 600 psig. Also, the plant may be called upon to operate through this entire range of pressures within a 24 hour period. A compressor plant designed and built for the fixed average conditions will perform in an unsatisfactory manner when actually on the job. The compressor cylinders would have the engine either underloaded or heavily overloaded, the scrubber would be undersized for the low pressure and the shell too thin for the high pressure. The safety relief valve would be improperly set, the manifold piping too small. Although it could be made to operate, this operation would be neither safe nor efficient.

For that reason it requires experienced process engineering to properly size the cylinders, piping, manifolds, scrubbers and coils throughout the plant. And all this must be planned to fit compactly into a small area.

In their designs the engineers use standard components wherever possible to hold down initial cost, as well as cost for any modification that may be made later. By means of centralized purchasing, too, the manufacturer can take advantage of quantity buying. This also assures the manufacturing department of having enough necessary parts when needed without any waiting for the missing part.

In any compressor station there are several hundred separate components. These must be designed or selected to go together into a coordinated unit. Each part must be requisitioned, warehoused, inspected and finally built into the plant.

It is easy to see why a great deal of money, and time as well, can be saved by performing all the manufacturing operations, from engineering to final inspection, in one central location.

And you can readily visualize the expense of assembling all these parts, fitting them together in the field with field labor without the manufacturing facilities of a modern factory.

In the matter of foundations alone, which for the conventional stationary plant require careful designing, expensive forms and large masses of concrete, the packaged plant needs only a simple concrete slab at the location. Its rugged steel base is engineered to carry the load and is formed to the base of the compressor.

When the plant arrives at location, it is skidded onto the slab, grouted in and bolted. Then, only three connections are required to put it on stream — suction and discharge lines and fuel gas line. When these are hooked up you know that you are ready to go on stream. You don't have to worry about some small missing part delaying you for days.

Usually, one of these plants requires only a light shelter to keep off the rain, although some installations are completely enclosed.

In operation, as well as in installation, there are many factors that save money. We have just mentioned one in particular — the changing of a one-stage unit to a two-stage unit. Here, because provision is made in the design, the additional equipment may be added when required without expensive rebuilding.

Another great saving results from the fact that packaged plants require less attention. In fact it has been found by one large producer that those units that have regular attendants require more maintenance than those that are left alone. They can be left alone — except for routine checks — because of the automatic controls that act as watch dogs, 24 hours a day. Also, automatic controls do not tinker with the mechanism. If any irregularity in operation should develop, they immediately shut down the engine and wait for an experienced service man.

In some types of service, compressors may not be needed after a period of years. An example of this is depletion of gas wells. Oftentimes it is then desirable to move the plant to a new location where compression is needed. Here again, packaged plants save the producer. For almost all of the plant is salvageable. About the only thing which must be abandoned is the concrete slab on which the plant rests.

The entire unit may be moved intact to a new site, just as it was originally

TABLE 1. Cost estimate 3300 hp installation of packaged compressor plant.

Qty.	Item	Material	Labor	Total
6	550 hp packaged compressors	$483,000	.....	$483,000
	Freight	3,420	.....	3,420
	Handling charge	.....	.....	2,100
	Foundation and floor	3,700	7,350	11,050
	Grouting	.....	540	540
	Building	7,510	1,600	9,110
	Electrical	860	700	1,560
	Paint	100	600	700
	Miscellaneous piping	3,120	2,000	5,120
	Gas measuring and regulation equipment	3,000	1,800	4,800
	Miscellaneous labor-erection	.....	5,070	5,070
	Headers:			
	Suction	3,549	2,350	5,899
	Discharge	8,452	11,412	19,862
	Fencing	1,440	540	1,980
	Land (4 acres)	5,000	.....	5,000
	Grading and drainage	2,600	.....	2,600
	Engineering and design	.....	1,250	1,250
	Office building	1,200	800	2,000
	Furniture-office building	1,300	200	1,500
	Sub-totals (Less compressor costs)	45,249	38,312	
	Purchase costs & insurance	2,262	6,130	8,392
	Contractor's fee:			
	Tools			
	Overhead			
	Supervision			
	Profit			
	Supplies	.....	6,513	6,513
	Adding compressor costs	483,000	.....	.....
	Grand total	$530,511	$50,955	$581,466
	Based on 3300 hp — Cost per hp			$176.00

transported from the factory and put on stream again after making the same three simple connections required at the first location.

In the preceding part of this paper we have attempted to show how, by standardization, quantity purchasing and factory manufacturing, the cost of the packaged compressor plant can be held to a minimum.

Table 1 tabulates the actual costs, completely installed, of a 3300 hp plant, comprised of six 550 hp compressors. This table shows that the completely installed cost is $176, per horsepower. To those of you who have had experience with the permanent type installation of compressor stations, this will no doubt seem to be a very low figure, for you would normally expect this cost to run from $250 to $300 per horsepower. The figures here speak for themselves, however, and are taken from an actual bid. I would like to point out, however, that to get these low figures it is absolutely imperative that the plant be completely designed and every piece be fabricated in the plant or factory and installed on the base before shipment to the job. For every item of work that has to be done in the field, the costs go up.

We have spoken earlier of the low operational cost to be expected from the packaged-type installation. Table 2 shows a comparison between an installation of packaged compressor plants and a permanent type station. Column 1 shows the actual operating and maintenance costs of a 1200 hp packaged compressor plant consisting of four 300 hp units for a period of 11 months. You will note that the operating cost per brake horsepower per year is $13.50 and that maintenance cost per brake

TABLE 2. Comparison—operating and maintenance costs. Actual cost records from one of the largest gas companies in the U. S. A.

	*No. 1	*No. 2
Brake horsepower hours operated	2,223,511	22,598,793
Operating labor cost	$ 7,393	$36,699
Fuel cost at 5 cents per mcf	2,523	12,655
Lube oil at 60 cents per gal	2,393	4,127
Other supplies	439	418
Automotive	8	446
Other expenses	587	2,702
Electric power	279	7,182
Overhead expense	1,230	6,612
Sub-total	$14,852	$70,841
Operating cost per brake horsepower per year	$13.50	$17.70
Maintenance:		
Labor	$ 792	$5,445
Material and supplies	1,385	3,505
Automotive	.....	401
Other expenses	475	1,548
Overhead	110	694
Total	$17,614	$82,434
Maintenance cost per horsepower per year	$2.50	$2.90
Total operating and maintenance cost per brake hp per year	$16.00	$20.60

*No. 1 is a 1200 horsepower packaged type compressor station semi-manned. Operating period is eleven (11) months. Brake horsepower hours operated indicate actual brake horsepower hours compressing gas only. The compressors are equipped with automatic unloaders and float on the line at half speed completely unloaded, until the line pressure falls below a predetermined point.

No. 2 is a 4000 horsepower fully manned station using two men per shift with relief crew (approx. fifteen men). Operating period twelve (12) months.

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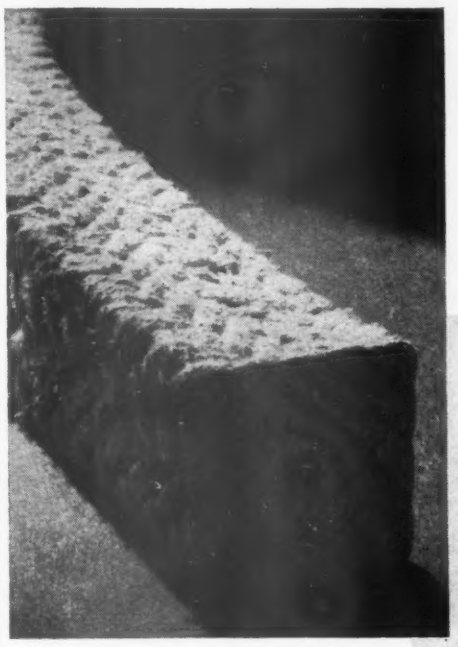

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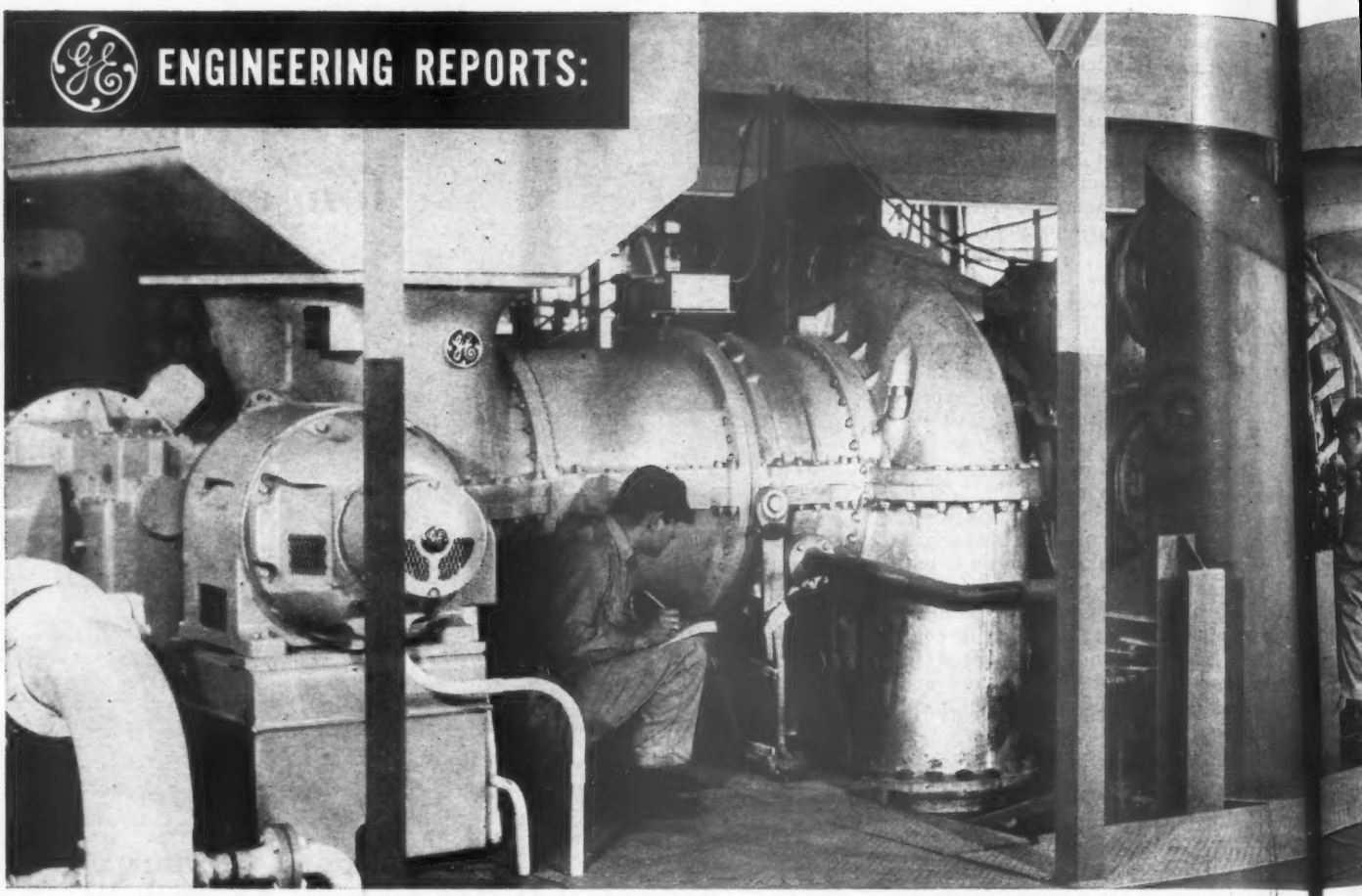
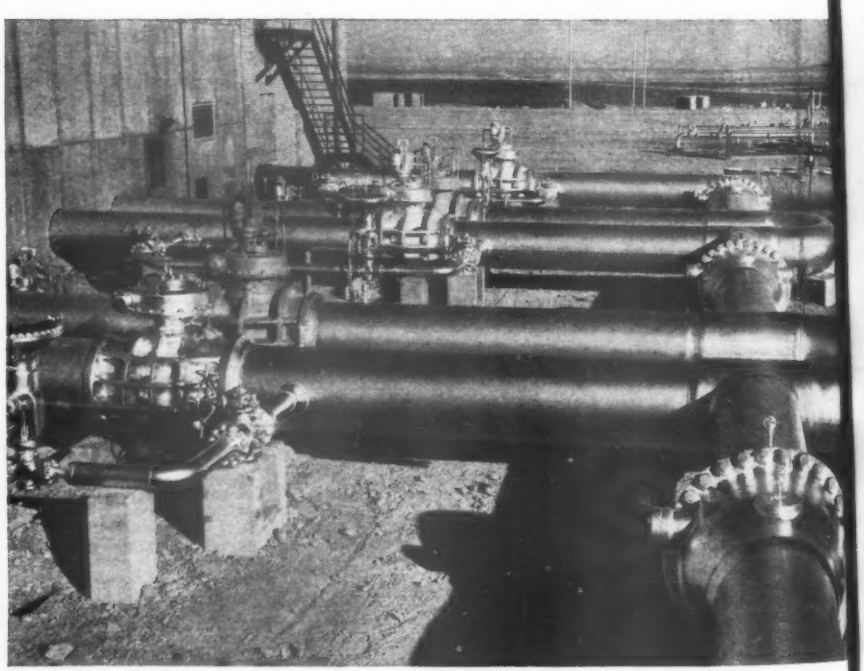


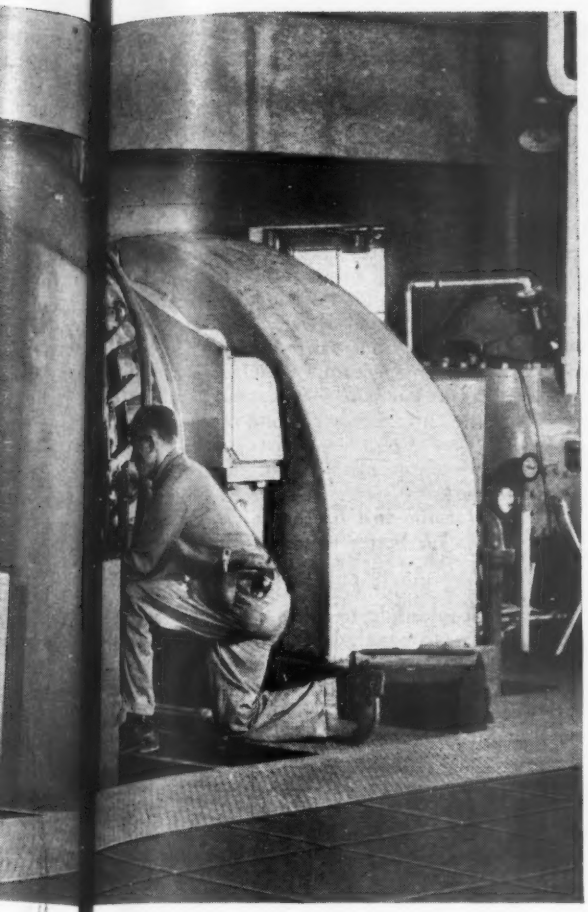
This G-E gas turbine is the first of 28 installed for gas pipeline pumping by the El Paso Natural Gas Co.

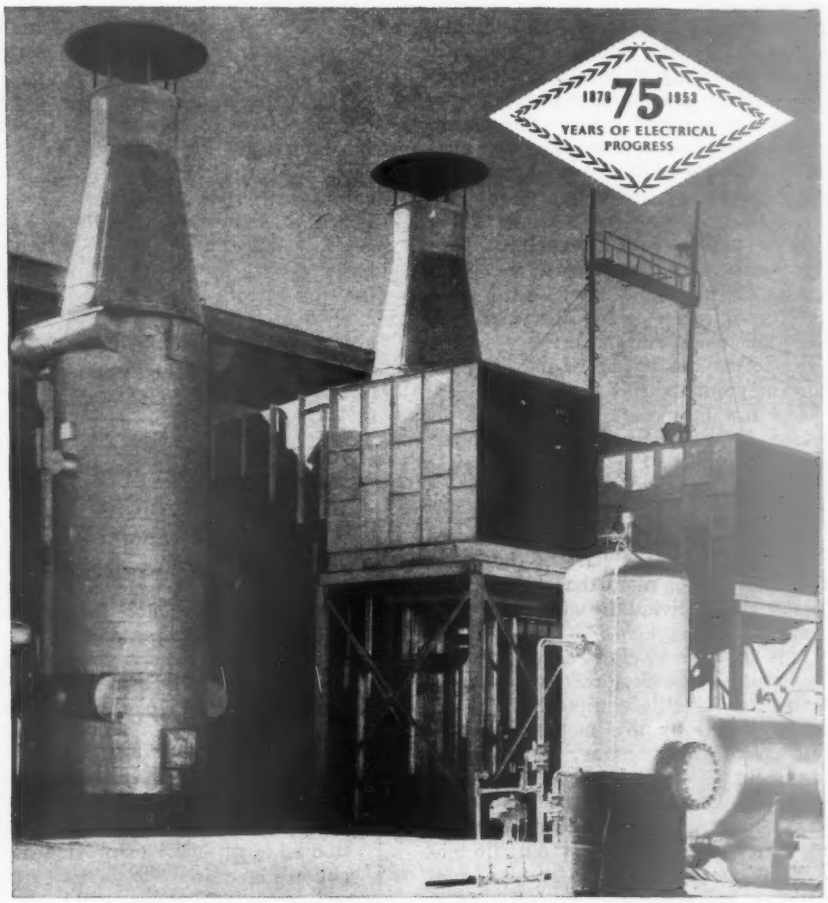
El Paso reports performance of G-E

NO OUTSIDE POWER IS NEEDED—panel above provides control for station auxiliaries. Auxiliary generator, driven by the turbine, provides all a-c power while turbine is operating.



MAIN GAS PIPING is simplified by use of gas turbine-driven centrifugal compressors. The suction and discharge valves, purging and pressurizing valves are all controlled automatically on start. The G-E gas turbine is automatically loaded, and the station discharge pressure is maintained automatically.





HIGHER EFFICIENCY—regenerators "recapture" waste heat, enable turbines to pump with efficiencies comparable to other types of power plants.

gas turbines exceeds expectations

Records of first 15 combustion gas turbines used for pipeline pumping show they start fast, save fuel, simplify operation

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4. **Personnel training system is highly satisfactory.** Key El Paso personnel were sent to the G-E gas turbine plant for intensified training. They in turn trained regular operating staffs. All new positions have been filled by company personnel.

G-E system engineers will be working closely with El Paso engineers during installation of the 13 combustion gas turbines still to go on the line. Your G-E Apparatus Sales Representative can tell you more about their services—and about the G-E gas turbine. Ask him also, to arrange for a showing of the new full-color film, "The El Paso Story," or write to General Electric Company, Schenectady 5, New York. 661-41

Combustion Gas Turbines for the Gas Pipeline Industry—Backed by 45 years of Turbine Leadership

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horsepower per year is $2.50, making a total of $16.00. Column 2 shows the actual operating and maintenance costs of a 4000 hp permanently installed compressor station and covers an operating period of twelve months. The operating costs per brake horsepower per year is $17.70 and the maintenance cost per brake horsepower per year is $2.90, making a total of $20.60. Here again, the figures speak for themselves. Needless to say, this operator uses the packaged compressor plant wherever possible in his operations. These figures serve to emphasize one of the most important points of this discussion.

The low first cost should not be obtained by sacrificing either completeness or quality. For any given job a definite amount of equipment is required.

It is more economical to purchase this equipment as a part of the packaged compressor plant than to purchase these parts individually and have them installed in the field.

It is possible to effect a considerable reduction in the first cost by lowering the quality of this equipment. Any reduction made by this means, however, will be offset by higher maintenance costs and these higher costs are with you as long as you operate the equipment. Along with the expense of replacing parts that have worn out, do not overlook the fact that you are *not compressing gas while the mechanic is at work.* The cost of lost production does not show in an operating and maintenance statement, but in the writer's opinion, it should be included.

The manufacturers of ball and roller bearings have established a life factor for their product. The purchaser can select a bearing for his particular application with reasonable assurance that it will have a definite operating life. While compressors are not sold on this basis, the fact remains that the same limiting factors are there.

With high speed, automotive type engines driving light weight, intermittent duty, air compressors that have been adapted to gas service, some saving in first cost can be shown. Maintenance and operating cost, as well as down time, will be increased over that of the heavy duty equipment if this type of unit is subjected to continuous 24 hour per day operation. The reason is quite plain, the components were neither designed nor built for this duty. When used in the service for which they were designed, both the engine and the compressor will give excellent performance. Most jobs of gas compression in the oil and gas fields do not fall within this classification.

The heavy duty, direct connected, gas engine driven compressor, of the sizes used in packaged compressor plants, can be expected to operate continuously for from twenty to thirty years. With proper preventive maintenance, they can be expected to operate 24 hours per day for the full life span.

It is far better to be able to shut the plant down at your convenience for periodic maintenance, than to be called out at midnight to make a major repair.

Now, to conclude this discussion let's summarize the main points that have been covered in detail. A packaged compressor plant is a complete plant — it is fully assembled at the factory — it is compact enough to be transported on oil field trucks. It is adaptable to any use where gas or air must be compressed. Whether used as single units or in large banks of many units, it has been found to reduce the cost of installation and to save on maintenance expense. * * *

Gasoline Studied In Research Project

Mr. Average Motorist may not realize it, but every gallon of modern gasoline contains from 3500 to 5000 different chemical compounds made up of hydrogen and carbon. Each of these compounds has a "personality" all its own. A research project to make, purify and engine-test as many of these compounds as possible was begun 15 years ago by American Petroleum Institute. Experimental fuels costing over $1300 a gallon are being studied in an effort to provide the nation's motorists with gasolines of still greater efficiency.

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PETROLEUM ELECTRIC Power Association officers and board of directors named recently are: Seated, Thomas E. Graham, Oklahoma Gas and Electric; Ned W. Beaudreau, Central Power and Light; Fred B. Clark, Arkansas Power and Light, secretary-treasurer; James E. Moody, Southwestern Gas and Electric, president, and W. L. Pearson, Southwestern Public Service, vice president. Standing, Kirby Dawkins, West Texas Utilities, board of directors; Fred Woerner, Texas Electric Service; Willis Frohock, Kansas City Power and Light; Harvey Cherry, Houston Lighting and Power; V. H. Ohrman, Texas Power and Light, and Tom D. Hoskins, Louisiana Power and Light. Not present, Henry C. LeVois, Gulf States Utilities Company.

Output Cut in Most Oil Producing States

Texas is producing 140,531 bbl per day less this month than last, due to a cut in allowables made by the Railroad Commission. This is the third month that output has dropped.

New quota is 2,803,528 bbl daily, 360,374 bbl below the level reached late in July, before the maximum production began dropping.

Texas Independent Producers and Royalty Owners Association answered the cut order with charges that importers are bringing in more and more oil while domestic production is being reduced in an attempt to bring down high inventories.

Although other states have been having their troubles, too, with lowered oil output, Louisiana, third largest oil producing state, increased its allowable for this month.

A 20 per cent cutback in New Mexico's maximum permissible flow for this month has been recommended by the state's oil conservation commission engineer. Elvis Utz, the engineer, recommended a basic daily output of 213,787 bbl in addition to 2400 bbl of northwest New Mexico production and 10,000 bbl allowed for new wells. October's output was 215,785 bbl.

In Kansas oil men observed a 10-day ban on oil production last month at the direction of the Kansas Corporation Commission. More than 25,000 producing wells were ordered shut down after above-ground storage reached what the commission termed "excessive." Only wells that produced during the shutdown were those flowing from waterflooding operations.

At the same time Oklahoma was feeling the effects of a cutback in allowables. October's production was 30 per cent that of August with November's expected to be approximately the same as the month before.

PEPA Elects Officers At Annual Convention

The Petroleum Electric Power Association elected officers and directors for the year 1954 at its annual convention held in Kansas City recently. New president is James E. Moody, Southwestern Gas and Electric Company; W. L. Pearson, Southwestern Public Service, vice president, and Fred B. Clark, Arkansas Power and Light, secretary-treasurer.

This is the silver anniversary of this organization, which was formed in Kansas City in 1926 to promote the use of purchased electric power by the petroleum industry.

Continental Wins Top Award on Annual Report

In the final ratings of the independent board of judges in the thirteenth survey of 5000 annual reports, conducted by "Financial World," Continental Oil Company was judged as having the best annual report of the petroleum industry for the first time. The bronze "Oscar of Industry" trophy was presented to L. F. McCollum, president of the company, at the Annual Awards Banquet in the Grand Ballroom of the Hotel Statler, New York, on October 26, 1953.

In this industrial classification Gulf Oil Corporation was runner-up for top honors, while Creole Petroleum Corporation placed third.

New Service Announced

Petroleum Information has announced formation of a new oil publication.

Called "Oil In The Rockies" the new service combines a map of the Rocky Mountain region on which progress of all exploratory drilling is noted, with a concise review of each month's activities in all phases of the oil industry in the region.

Oil In The Rockies will be issued monthly as an analysis and forecast of activities in exploration, drilling, refining, pipelining. It will also present reviews and summaries of outstanding regional operations.

PART OF a $5,000,000 natural gasoline plant being built in the Pledger field, near West Columbia, Texas, for Southern Production and Humble Oil and Refining Companies. Stearns-Rogers Manufacturing Company is building the plant. Unit is 154 ft OD by 124 ft long, and estimated weight is 205,000 lb. Railroads handling the shipment have scheduled it to travel only in daylight, at no more than 25 miles per hour. All railroad clearances between the Stearns-Rogers shop and plant site were carefully checked and special routing arranged so that shipment will not travel on outside of curve while another train is on adjoining track.

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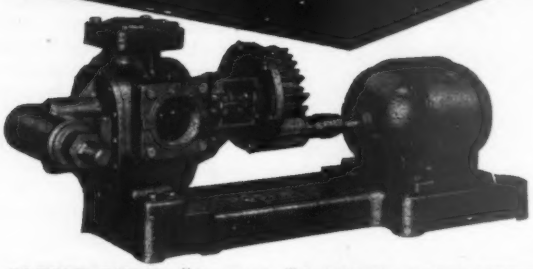

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Write: C. L. Laue, 26 Broadway, New York 4, New York

Wanted soon: Used natural gasoline plant to extract natural gasoline, butane and propane to handle 4 to 8 million C. F. daily wet gas. Goodalls, Ogallala, Nebr.

FOR SALE — ELI Model M-6 portable drilling rig on GMC Truck. Ideal for water wells. Will consider good spudder as trade. Vaughn & Taylor Construction Co., Inc., 2103 North Grant, Odessa, Texas, Phone 7-2091.

NEWS

PAD May Be Abolished

The Petroleum Administration for Defense, already cut to the bone in personnel, may be in for final abolition in a few months, and some officials believe it may expire January 1. H. A. Stewart, acting deputy administrator of PAD has asked Walter S. Hallanan, National Petroleum Council, to name a committee to study organization of a peacetime setup to deal with oil and gas problems in case PAD is done away with. This Hallanan has done, and has named B. Brewster Jennings, president, Socony-Vacuum Oil, as chairman.

Stewart in a letter to Hallanan recommended that PAD be liquidated as soon as it has completed its "emergency defense responsibilities" suggesting that any long range problems in the oil and gas industries remaining after the abolition of PAD could be handled by a "normal peacetime organization," such as the Interior Department's oil and gas division.

Alaska Governor Asks Freeing of Point Barrow

Governor Heintzleman of Alaska has been in Washington recently asking release of the Point Barrow Naval Petroleum Reserve for oil and gas exploration by private industry now that the Navy is abandoning its exploration work there.

Heintzleman also asked the Interior Department to release some 37,000 sq miles on the Arctic slopes north of the Brooks Range, for private exploration. This area borders the Umiat region where the Navy drilled a number of test wells.

Sun Dedicates Building

Sun Oil Company dedicated a new office building at Smiths Bluff, near Beaumont, Texas, as part of its Oil Progress Week celebration recently.

The one-story, air-conditioned masonry building will house personnel in charge of Sun's blending and packaging plant, laboratory, warehouse, package dock, and the distribution of bulk and packaged lubricating oils, waxes and specialties.

Containing office space for A. S. Johnson, manager; H. W. Hillis, assistant manager John W. Shaw, foreman; and the clerical force required for the operation, the building covers approximately 1200 sq ft.

New Tide Water Thrift Plan

Stockholders of Tide Water Associated Oil Company have aproved adoption of a thrift plan for employees of the company and certain subsidiaries, according to an announcement released by D. T. Staples, Tide Water Associated president. The plan provides that participating employees may elect to save from their monthly compensation an amount not exceeding approximately 5 per cent of their base compensation. The company will contribute an amount equal to 50 per cent of the savings allotment of each participating employee.

New Provisions May Hamper Sale of Rubber Facilities

Sale of synthetic rubber plants owned by the government has been hampered by recent legislation passed in Congress. Approval of the sale was made by President Eisenhower August 7, when he recommended a three-man commission to handle negotiations. To date only two of the men have been named by the President and it has not been announced who, nor when, the third man will be named.

The first bill introduced into the House provided for 90 days bidding period and 4 months negotiation period, but the Senate has changed the bill to a 6 months' bidding period and the latter provision to 7 months. Also the Senate added an amendment that provides that any single item in the sale could be rejected by Congress at the last minute, however, this amendment was changed later to give buyers the right to withdraw their offers should Congress refuse to sell any facility.

A further amendment provides that the attorney general give a written opinion to the effect that provisions of sale of the synthetic rubber plants are not inconsistent with the antitrust laws. Previously the Department of Justice had expressed a verbal opinion that the sale was within the bounds of antitrust limitations. Some observers think the attorney general might not make such a written statement as it might possibly be used against him in further antitrust actions. Should he refuse, no disposal program could be carried out.

Oil Imports Up in U. S.

Total crude imports of oil into the United states were back up to the 1,000,000-bbl per day mark for the week ending October 10, according to a report by the American Petroleum Institute.

Import total was 1,020,200 bbl per day and 1,261,600 bbl per day the week before. For the same week a year ago the total was 905,300 bbl per day.

Week ended	Crude oil	Residual fuel oil	Distillate fuel oil asphalt, etc.	U. S. total
September 12..	598,200	342,600	5,000	945,900
September 19..	698,700	347,500	42,000	1,088,200
September 26..	489,800	293,600	20,300	863,000
October 3.....	720,100	369,900	45,000	1,261,600
October 10....	650,400	209,700	23,000	1,020,200

Liquid Evaporation Study Will Be Made by API

A new committee to study losses of petroleum liquids by evaporation has been appointed by President Frank M. Porter, of the American Petroleum Institute. J. H. McClintock, of Esso Standard Oil Company, New York, was named chairman.

The group is to be known formally as the Committee on Evaporation Loss. The specific scope of its activities will be "the development of factors governing the evaporation loss of petroleum liquids for use in the solution of operating problems."

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A tremendous variety of fluid mixing needs are ably handled by the complete line of Eastern Mixers. Size and power of mixers are flexible to help solve your problems. For complete information and engineering data, write for Eastern Fluid Mixing Catalogs. Eastern engineers are always available to work out your complex mixing problems with you.

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Eastern INDUSTRIES, INC.
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Scientifically controlled tests, impartially conducted, to determine the comparative accuracy of several flowmeters of popular designs have conclusively proved the superior advantages of Barton's Dual-Bellows meter body. The Barton was the only flowmeter that averaged less than 1% deviation from perfect calibration over a 100°F change in meter temperature; others tested deviated as much as 3%. The ingeniously engineered Barton Meter Body insures a higher order of accuracy when the instrument is subjected to normal day and night air temperature variations.

Sustained accuracy is one outstanding Barton flowmeter advantage. In addition, the actuating element is compact, rupture-proof, yet highly sensitive, insuring a long life with high responsiveness. Problems associated with mercury, pressure bearings and over-ranging are eliminated.

Externally adjustable pulsation dampner eliminates pen flutter and chart painting. Torque tube drive assures absence of leakage and friction. Barton flowmeters are completely self-draining, or venting...need no sealpots. *Install cost-cutting Barton flowmeters.*

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sustained accuracy

lowest maintenance

COST-REDUCING FEATURES..

- No Mercury
- No Seal Pots
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*Pat. Nos. 2400048, 2500360, 2590324, other patents pending.

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NEWS

Brazil Oil Law Excludes All Foreign Interests

Brazil has signed a new oil bill excluding all foreign interests in its oil industry. The new law created an oil monopoly with exclusive control of oil production, transportation, and refining.

Under the new bill a corporation, government controlled, has been created called the "Petroleo Brasileiro S. A." which will operate under the name of Petrobras. The corporation will have an initial capitalization of the equivalent of $200,000,000, which will be increased by 1957 to $500,000,000.

The government plans ultimately to obtain 51 per cent of the stock, with the remainder open to public subscriptions, but foreigners may not be shareholders, nor may Brazilians married to foreigners.

Japan Signs Contract To Import Iranian Oil

The Japanese and Iran have signed a five-year contract to import Iranian oil into Japan, the Asahi newspaper reported. Director Juro Ishizaki of Daikyo Oil Company was quoted as saying the barter agreement was signed in August.

Report of the agreement said the Japanese company will exchange several tankers and freighters for Iranian crude oil. It was also reported that Idemitsu Kosan trading firm, another Japanese firm, is negotiating another trade agreement with Iran.

Meanwhile in Iran a radio broadcast from Tehran reported that the new government may be ready to deal with foreign interests to get its oil production restored.

Saudi-Arabian Output

Crude oil production in Saudi Arabia during August amounted to 26,555,539 bbl, or an average of 856,630 bbl per calendar day, it was announced by the Arabian American Oil Company.

Crude oil production for the first eight months of 1953 amounted to 205,804,092 bbl, an average of 846,930 bbl per calendar day.

PAD to Suspend Order 3

Because current supplies of aviation gasoline are sufficient to meet all immediate essential needs, PAD Order No. 3 will be suspended for the period from October 1 to the end of December, PAD announced.

PAD Order No. 3 prohibited the use of alkylate in automotive gasoline and defined PAD's powers to direct the use of aviation-gasoline components for maximum production of higher octane number avgas.

Two conditions make the suspension of the order at this time possible:

1. Production of aviation gasoline a recently completed PAD survey ha revealed, is greater than was predicte earlier this year.

2. Because the supply of plate ste has continued to be tight, not all of t storage scheduled has been complet

Standard Indiana Builds Warehouse Office Unit

Standard Oil Company has begun construction of a combination district office, warehouse, and maintenance building at Chillicothe, Missouri, it was announced by Sam L. Jackson, manager of products pipe lines. The one-story building, designed by Lundstrum and Skubic, Inc., of Chicago, will have about 6280 sq ft of floor space. It will be a steel frame structural tile building, basically 40 ft by 140 ft. An office space with face brick exterior will project about 17 ft by 40 ft in the front of the building.

The Chillicothe district of Standard's products pipe line department will be in the building, as will the district's maintenance crew. This district includes the company's Neodesha, Kansas-Sugar Creek, Missouri, and Sugar Creek-Dubuque pipe lines, under T. A. Shedd, district superintendent.

Douglas Oil to Launch Drilling Program in Peru

Douglas Oil Company of California has acquired operating rights on more than 1000 acres of proved oil land in northern Peru, and arrangements have been made to launch an extensive drilling program this month, President W. G. Krieger announced. Krieger said an agreement has been signed with Compania Petrolera Lobitos, a subsidiary of a British Company, Lobitos Oilfields, Ltd., covering all of Lobito's Continental Shelf concessions in the Lobitos area. The property lies offshore and is contiguous to the presently producing Lobitos oil field. Oil produced in the area is 37 deg gravity, especially suitable for Douglas' refining operations.

Krieger said that reports from Dean H. Sheldon and Peter H. Gardett, consulting geologists and engineers, indicate that virtually all of the 1000 acres in the Lobitos area is proved oil land. There are at least five producing zones in that area, at depths ranging from 1100 to 7500 ft. Richest of these, the Parinas zone at 4600 ft, was estimated to contain 15,000 bbl per acre of recoverable oil, with 12 to 20 per cent additional recovery possible through the use of gas injection and repressuring methods.

Alaska, Some States Receive Large Revenues

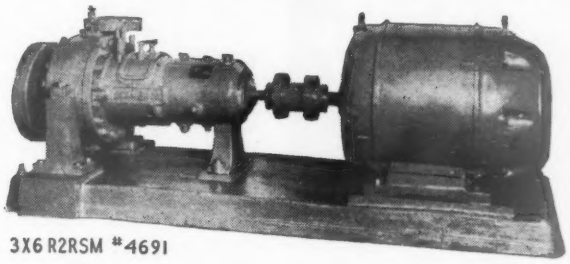
Alaska and 22 states will receive $17,255,527 from the Interior Department as their share of government revenue from mineral leases and permits during the fiscal year 1953. This amount is chiefly from oil and gas.

Almost two-thirds of the $24,115,375 distributed by the Bureau of Land Management under the various laws giving the states a share in the revenues from sale of public lands and timber and grazing on public lands is included in the lease money.

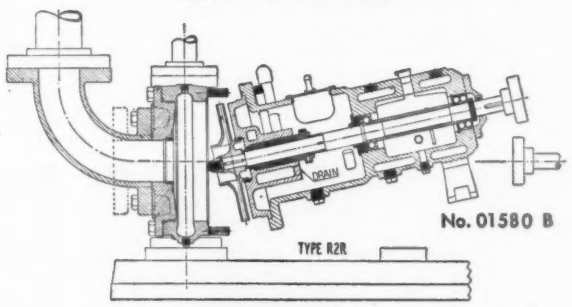
Wyoming, California, New Mexico, Montana, and Utah will receive most of the money from leases and permits.

DEAN BROTHERS PUMPS INC.

Type R2R Centrifugal Process Pumps



Type R2R Process Pump



Type R2R Process Pump

DISASSEMBLY: The Type R2R process pumps can be disassembled without disconnecting the suction and discharge piping. By first removing the spacer from the spacer type coupling, and unbolting the casing from the cradle the entire cradle and complete rotating element can be removed without disturbing the suction and discharge piping.

OPERATING RANGE: Type R2R, Heavy duty, process pumps are available in eighteen different sizes, enabling our engineers to furnish units specially designed and constructed for the particular work to be performed.
Capacities: 50 to 2000 Gallons per minute.
Heads: Up to 400'. Speeds: 900 RPM to 4000 RPM.

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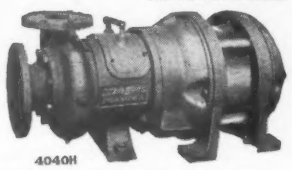
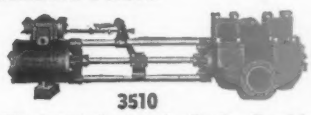
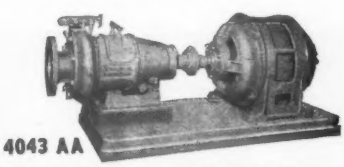
CENTRIFUGAL AND RECIPROCATING PUMPS



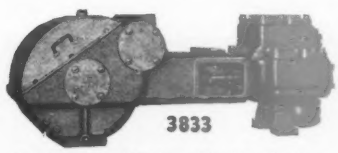
Close Coupled Centrifugal Pump



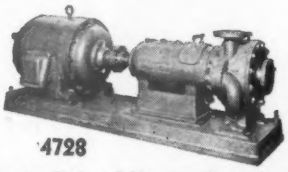
Horizontal, Single Style, Double Acting, Piston Type, Close Clearance Pump. Designed to handle volatile liquids



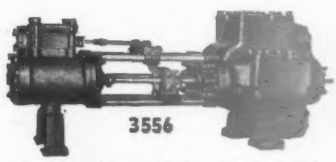
Pedestal Mounted Centrifugal Pump



Horizontal, Duplex, Double Acting, Side Pot, Piston Type, Oil Bath Power Pump



Double Pedestal Bearing Centrifugal Pump



Durable Duplex Packed Piston Pattern Steam Pump, Side Pot Type

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Representatives in Principal Cities

NEW YORK Chapter of Nomads was host to a Fall Golf Party at Baltusrol Golf Club, Springfield, New Jersey, recently. Winners and foreign visitors are shown. Longest drive and high gross winners: Eric Bergstrom, Socony-Vacuum (guest —longest drive); E. F. Andreason, George P. Gregory (Nomad—high gross); Walter D. Wood, A. O. Smith (Nomad—longest drive).

Shell Oil Produces New Film on Fossils

Modern living is vitally affected by fossils of plants and animals that lived centuries ago. This is the theme of "The Fossil Story," newest film to be released by Shell Oil Company. Photographed in full color, the 16mm sound motion picture shows clearly how men in industries such as oil and steel utilize vestiges of prehistoric life in their important work. Petroleum companies, for example, have laboratories devoted exclusively to the study and classification of fossils, which are one of the most important clues for identifying underground rock structures that may contain oil.

"The Fossil Story" runs 19 minutes. It is available free upon written request to the Shell Film Library, Room 4226, 50 West 50th Street, New York 20, New York, and 100 Bush Street, San Francisco, California.

New Suit Reported In Tideland Oil Law

Latest report in the Tidelands Law controversy is that Rhode Island will file a new suit testing constitutionality of the law, but unlike Arkansas, will sue Louisiana, Texas, California. Bone of contention is the $70,000,000 held in escrow by the Federal government. With the passing of the States' Rights Tidelands Law in June, the money automatically belongs to the tidelands state, as it is "tidelands oil" revenues held until a decision was made by the courts as to who should have it.

In Louisiana Interior Secretary McKay gave assurance that the Continental shelf rights of that state and other coastal states will be of "primary concern" to his department. Dedicating the new Lafayette Oil Center, McKay declared, "we must make sure there is no invasion of these rights."

LOW GROSS WINNERS: John Evans, Lucey Export (Nomad — 1st); G. R. Weeks, Texaco (Guest — 1st); Herb Maland, R. J. Eiche and Associates, (President's Cup); R. T. Meek, Ladish (Nomad — 2nd); W. H. Dickinson, Standard Development (Guest — 2nd).

FOREIGN VISITORS: Clark Elder, Mene Grande Oil Company, Venezuela; Milt O. Smith, Arabian American Oil Company, Saudi Arabia; Guy Daniels, Mexico; Jim Roman, Standard Vacuum Oil Company, Sumatra; Carl Whigham, California Texas Oil Company, Sumatra.

FEWEST PUTTS AND NEAREST TO PIN WINNERS: J. Brameier, Texaco (Guest — fewest putts); Joseph Chanda, A. C. Smith (Nomad — fewest putts); Holland Smith, Holland Smith (Nomad), and J. Steele, Buckeye, (Guest — nearest to pin).

LOW NET WINNERS: E. R. Smoley, Lummus (Nomad — 1st); Paul Nagle, Baash-Ross (Guest — 2nd); W. B. Ashland, Dalc, (Nomad — 2nd); A. J. Laycock, Foster Wheeler (Guest — 1st).

Mrs. William C. Black, of Ithaca, New York, was named at the National Safety Congress as top individual winner of 1953 for the annual Carol Lane Awards honoring outstanding contributions to traffic safety among contestants from all parts of the United States. Mrs. Black was cited for organizing safety programs whose results included an increase in school crossing guards and reduction of speed limits.

The top award for organizations contributing to traffic safety went to the Orlando, Florida, Fourth District of Pilot International. This group organized a unique rural program under which highway safety is provided for children boarding and alighting from school buses, for car and truck drivers making emergency stops and for rural letter carriers.

First prizes in both individual and organization sections of the awards consist of a $1000 defense bond and a bronze statuette symbolizing "women's protective instinct."

R. D. Rogers has been appointed a vice president of Tide Water Associated Oil Company, and vice chairman of the operating committee, Eastern division, according to announcement by President D. T. Staples. Rogers, recently appointed manager of the transportation and supply department, Eastern division, with headquarters in New York City, has been in the service of Tide Water Associated and its predecessor companies for more than 30 years.

Floyd W. Findley has been named division safety supervisor in charge of accident and fire prevention activities with the Shreveport, Louisiana, division. Findley has been employed with Ohio since 1933.

Robert Siegel, who joined the company as an office boy in 1920, and has been associated with foreign oil producing activities during most of his career, was elected a director and executive in charge of Middle East affairs of Socony-Vacuum Oil Company, Inc. He fills a vacancy on the board of directors left by the death of Charles L. Harding.

Siegel attended night classes at New York University under the company's education plan and received his bachelor of science degree in 1932.

H. Wilkinson

K. King

G. S. Brown

Harold Wilkinson, C. M. G., a director of The "Shell" Transport and Trading Company, Ltd., has been appointed a director of two other companies in the Royal Dutch Shell Group— The Anglo-Saxon Petroleum Company, Limited and The Shell Petroleum Company Limited. Wilkinson joined The Asiatic (now The Shell) Petroleum Company Ltd. in 1922. In 1924 he went to Singapore and served there for four years before being transferred to Shell Company of South Africa Ltd. In 1931 he went to the United States where, some five years later, he was appointed president of Asiatic Petroleum Corporation, New York. He is also president of Shell Caribbean Petroleum Company. In January 1949 he was elected to the board of The "Shell" Transport and Trading Company, Ltd.

Kerryn King has been named public relations director of The Texas Company. King is senior vice president of Hill and Knowlton, Inc., public relations counsel for The Texas Company.

King has been associated with Hill and Knowlton, Inc., since 1943 and has been in charge of its work for Texaco. King was graduated from Southern Methodist University with a BS in journalism in 1939.

G. Stewart Brown, public relations manager of Standard Oil Company of California, San Francisco, has been elected National Chairman of the Oil Industry Information Committee for 1954. Brown, on January 1, will succeed **Stanton K. Smith,** president of Smith Oil and Refining Company, Rockford, Illinois. He was elected unanimously at a recent meeting of the National Committee, which directs the industry-wide public relations program sponsored by the American Petroleum Institute.

Vice chairmen elected were:

Richard Rollins, secretary, Atlantic Refining, Philadelphia, Pennsylvania; **W. R. Huber,** general manager of retail sales, Gulf Oil, Pittsburgh; **Douglas Campbell,** public relations director, Pure Oil, Chicago, Illinois; **A. D. Eubank,** division manager, Quaker State Oil and Refining Company, Kansas City.

John S. Cooke, of the American Petroleum Institute, New York, was re-elected secretary.

W. M. Vaughey

W. M. Vaughey of Jackson, Mississippi, has been named president of the Independent Petroleum Association of America, succeeding Charlton H. Lyons of Shreveport, Louisiana. Named treasurer was **C. L. McMahon,** the only other new officer, succeeding D. R. Snow, both of Tulsa, Oklahoma.

Vaughey, a partner in the firm Vaughey and Vaughey, entered the oil industry in 1925, at that time joining Philmack Oil Company. In 1937 he and his brother Emmett formed the firm of which he is now partner, with headquarters in Jackson, Mississippi.

New vice presidents elected include: Paul C. McDonald, Eldorado, Arkansas; C. Richardson Collins, Mount Evansville, Indiana; A. J. Boundy, Wichita, Kansas; V. O. Sims, Owensboro, Kentucky; A. R. Wherritt, Shreveport; Alex J. Brunini, Vicksburg, Mississippi; A. R. Jones, Kansas City, Missouri; Winston L. Cox, Billings, Montana; Harvey E. Yates, Artesia, New Mexico; Knight Thornton, Wellsville, New York; W. E. Shrider, Hebron, Ohio; Watson W. Wise, Tyler; J. Harold Dunn, Amarillo, and J. R. Butler, Houston. Texas.

New executive committeemen named were John E. Howell, Eldorado; R. B. Parriott, Wichita; Gilbert J. Mueller, Denver; George B. Cree, Pampa; F. Wayne Fesenmyer, Bradford, Pennsylvania; F. J. Danglade, Lovington, New Mexico, and Roland V. Rodman, Oklahoma City.

J. P. Coleman of Wichita Falls was elected president of the National Stripper Well Association for another term. Also re-elected were H. M. McLure, Alma, Michigan, and Dave Scott, Bradford, vice presidents and Fred Sehmann of Wichita Falls, secretary-treasurer.

John W. Sparks, Jr., recently joined the oil staff of the *Tulsa World*. A member of *The World* oil staff some years before going as oil writer to the *Fort Worth Star-Telegram*, he has been engaged in publications and press relations work in Washington, D. C.

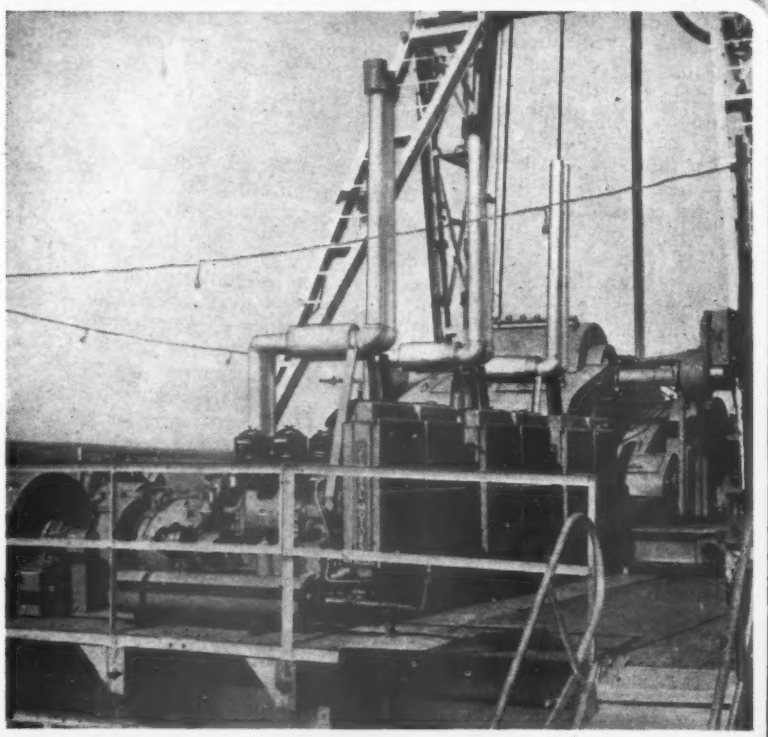
Dr. John Gaillard, mechanical engineer, staff of the American Standards Association, and lecturer at Columbia University, will hold his next five-day private seminar on industrial standardization from January 25 through 29, 1954, in the Engineering Societies Building, 29 West 39 Street, New York.

GM DIESEL
CASE HISTORY NO. 527-2

USER: Northern Development Co., of Tioga, N. Dakota, subsidiary of Regent Drilling Co., Edmonton, Alberta.

INSTALLATION: Three GM Diesel "Twin-6" torque converter units driving an Ideal 125 draw works and two Ideal C 350 mud pumps; GM 3-71 Diesel drives a generator set.

PERFORMANCE: Engines have operated 6,000 hours since they were installed, without causing delay or requiring repairs. Tool Pusher Bob Davidson says the engines are compact for their power and provide greater flexibility and better portability.



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GENERAL MOTORS
DIESEL POWER

"MORE POWER AT LOWER COST"
says user of 100 GM Diesels

This progressive drilling company now has more than 100 General Motors Diesels powering drilling rigs in the United States and Canada. For big operators or small, GM Diesels deliver the power drillers need. It is compact power—light in weight and easier to move. It is dependable power—the product of continuous research and improvement by General Motors engineers. It is quick-accelerating 2-cycle power for faster round trips and more time on bottom. And most important, it is economical power—economical to buy initially, economical to maintain through the years. GM Diesel engines, parts and service are available through a world-wide distributor organization. See the distributor nearest you for full details.

DETROIT DIESEL ENGINE DIVISION
GENERAL MOTORS • DETROIT 28, MICHIGAN
SINGLE ENGINES...16 to 275 H. P.
MULTIPLE UNITS...Up to 840 H. P.

Carl Hample, who has represented Stentz Equipment Company in Oklahoma and the Panhandle of Texas, passed away quite suddenly recently. He is well known to the petroleum industry, both in California and the Mid-Continent area, where he had spent the greater portion of his life in engineering and sales work.

He was graduated from McGill University with a Bachelor of Science in mechanical engineering in 1913.

Baron Z. M. de Wahrtreu, American Foreign Insurance Association, died recently. Commonly known as "Tommy" to his many friends and acquaintances, he had been ill for some time, having suffered a stroke. Baron de Wahrtreu joined the Association in 1923, and retired in 1934.

Clark T. Morse, prominent Detroit industrialist of Hillcrest Drive, Bloomfield Hills, Michigan, died September 18 in London, Ontario, after a brief illness. Morse was president of the American Blower Corporation of Dearborn, Michigan, and the Canadian Sirocco Company, Ltd., of Windsor, Ontario, Canada, as well as a director and member of the executive committee of the parent firm of those companies, American Radiator and Standard Sanitary Corporation.

John O. Larson, 39, director and executive vice president of Fischer and Porter Company, died September 18. He also served as a director of Fischer and Porter (Canada) Ltd., and of Alloy Steel Casting Company, Willow Grove, Pennsylvania, and was widely known as a specialist in industrial instrumentation. Larson had previously served as the company's sales manager, and as manager of its sales and engineering office in New York. He was graduated from the Illinois Institute of Technology in 1936.

H. N. "Scoop" Nelson, assistant sales manager, Findlay division, Gar Wood Industries, was killed September 29 in an automobile accident in Moorhead, Minnesota. He was 43 years old. Well known as "Scoop" throughout the construction industry, Nelson spent more than 20 years in the sales and service of heavy equipment. He joined Gar Wood in 1938 as a field service representative after eight years with R. G. Le Tourneau.

Joe Dunlap, accountant for Atlantic Refining Company, died October 19 at his home in Dallas, Texas. A graduate of the University of Texas, Dunlap joined Atlantic immediately upon graduation.

Louis Scholl, Jr., retired geophysical consultant for The Texas Company died recently. Scholl had retired December 31, 1952 after 36 years with the company.

A graduate of Carnegie Institute of Technology, Scholl was promoted to division geologist at Tulsa in 1918. In 1929 he became chief of the geophysical division, Houston, and in 1945 manager of the division. He was given the title he retired with in 1950.

Charles L. Harding, 47 years old, director and vice president in charge of Middle East affairs of Socony-Vacuum Oil Company, Inc., died recently. He had been a member of the Socony-Vacuum board of directors since 1948. He was graduated from Utah Agricultural College with a Bachelor of Science degree in 1928, and from the University of California.

Frank W. Skinner died on September 19, bringing to a close the career of one of California's pioneers. Skinner attended high school and subsequently University of California, after which he joined Standard Oil Company of California at Richmond where he was employed in the company's refinery.

Later he was transferred from manufacturing to production in the San Joaquin Valley. He moved to Whittier in 1922 and for many years traveled widely over Standard's operations as inspector of boilers and pressure vessels. He retired in 1946.

It takes modern equipment to find, produce and transport oil as fast as present demands require. It also takes modern oil field housing to satisfy families of workers. In order to make a better team in the oil fields you need good equipment plus modern housing for workers. STURDYBILT pioneered "city home" housing in oil field camps. STURDYBILT has kept pace with new designs and construction, and is STILL your best buy in oil field housing.

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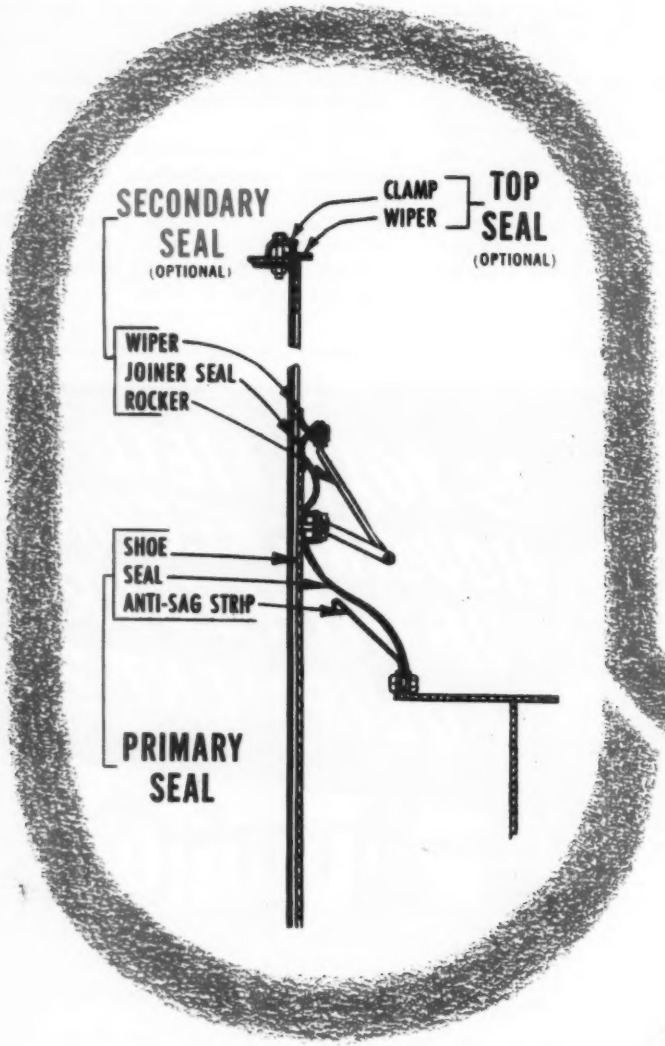
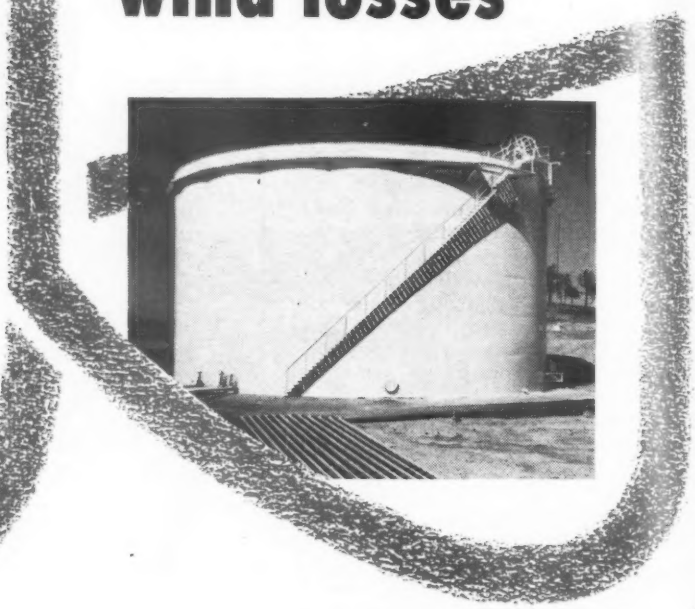


secondary seal to cut wind losses



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BOOKS

▸ **Synthetic Products of Petroleum,** *Volume V. Part II of Science of Petroleum, edited by Drs. A. E. Dunstan and B. T. Brooks. Oxford University Press, New York. Price, $35. Pages, 329.*

Technological advances are so rapid that it becomes necessary to bring up to date the work of the authors and editors of the first four volumes of this monumental work, compiled in 1937. This volume is the second part of three in Volume V, of which the first was published in 1945 and the third is to be completed, hopefully in the not too distant future. The editors here have attempted with excellent results to bring together the record of advances of the last 12 years in a greatly expanded field of endeavor that they acknowledge is international in scope and flavor.

The first section of the work is devoted to synthetic products, the second to refinery processes. Section I discusses seven divisions of the field of synthetics, and can boast of authors with such names as Hohenstein, Ipatieff, Frolich, Gilliland, Brooks, Haas, Cohan, Gilbert, and others, discussing the developments in hydrocarbon polymerization of paraffins and olefins, isobutylene polymerization, synthetic rubber polymerization, organic chemicals, nitroalkanes, carbon black and surface-active agents. Diagrams are employed profusely to illustrate especially molecular structures. Tabulations of properties and data on raw materials and finished products also sum up in minimum space and reading time the outstanding discoveries in recent years.

Five subdivisions of the second section take up as many major refinery process operations exhaustively, catalytic cracking, distillation, hydrogenation and dehydrogenation, alkylation, and what may be classed as refinery chemical treating processes. Literature references are exhaustive in number and in scope of the field covered; attention is given to specific problems and developments and both individual results obtained, and the chemical engineering of processing are covered generally in detail.

▸ **Oil in Florida.** *Review by the First Research Corporation, at the First National Bank Building. Miami 32, Florida. Price, $5.00.*

This paper bound, 8½ by 11 in., volume contains 22 pages and covers the history of the oil search and the results and a chapter on the oil geology of Florida. The concluding chapter, A Look at the Future, deals with the effect that the discovery of additional reserves will have on the general economy of the area.

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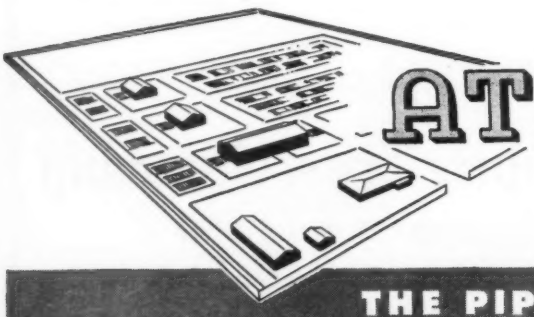

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WIRE LINES FOR ROTARY DRILLING
TON-MILE RECORDS AND CUTTING OFF PRACTICES

(Continued from Sheet 33)

Cutting off and Moving Rotary Lines to Distribute Wear and Fatigue

It is general practice in the rotary field to cut off regularly a section of rope from the drum end, and move the line to distribute more evenly the wear and fatigue, which is normally concentrated in relatively short sections of the line. It is the practice to purchase lines sufficiently long to permit several cut-offs during the life of the line, resulting in increased service per foot of line.

The main points of concentrated wear or bending occur at the following locations:

1. At the flange on the draw works drum where the line rises from one layer to the next, where the rope is subjected to abrasion and pinching.
2. Where the rope is in contact with the fast sheaves in the block when the load is accelerated from rest. Maximum bending occurs here.
3. Over the dead line sheave where bending is concentrated over a short section of line. This bending is particularly damaging when drilling in formations that cause bouncing or vibration of the drill pipe.

It is somewhat difficult to outline definite rules regarding the procedure to be followed in cutting off from the drum end. Procedures vary with various oil companies, and in different fields, and in each case the procedure followed has been developed through each company's individual experience.

The following recommended practice may be applied to lines of any length, if followed step by step.

(a) If ton-mile records have not been previously kept, figure from drilling reports the ton-mile service rendered by several previous lines of the same description and length, used on the same or similar rigs operating under reasonably similar conditions of depth and loading. Select a ton-mile record which represents good service, probably the line on which the ton-mile record was highest.

Use this ton-mile record as a basis of establishing the cut-off practice.

It will be necessary that a system be set up whereby trip-by-trip ton mile records are kept on each rig. This can be handled by the tool pusher, or the drillers, under his supervision. As each cut is made, the length of cut, and the ton-mile interval between cuts, should be recorded. This can best be done by using the "Rotary Drilling Line History" charts in the pocket on the inside back cover of this handbook.

(b) Calculate the amount of line remaining on the reserve spool after stringing up the derrick. This will be the amount of line available for cutting off.

(c) The recommended minimum length of cuts is 3½ times the drum circumference, and the maximum length is 150 feet, depending on the length of line. The minimum number of cuts recommended is 8.

Based upon the reserve line available for cutting, determine the number of cuts to be made, and the length of cuts, keeping within the above limits.

Since cutting the line results in down time on the rig, it should prove most economical to make cuts as long as possible within the above limits. Experience gained as this practice is followed will indicate the most economical combination under the conditions of operation.

(b) Having established the length of each cut and the number of cuts available in the reserve, divide the anticipated ton-mile service (service rendered by the representative line under "a") by the number of cuts to be made. The result is the ton-mile interval between cuts.

(e) At the established ton-mile intervals, cut off the calculated length of line from the drum end.

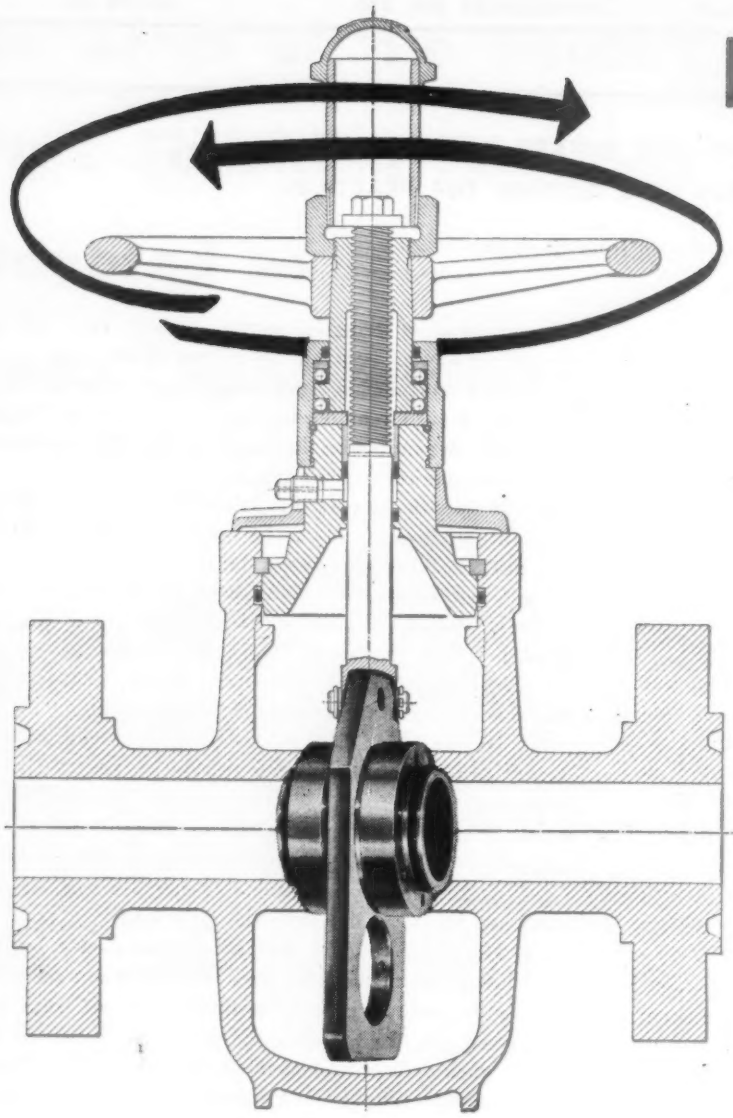
(f) The above practice should be accompanied by the usual inspection of the line, since conditions not reflected in ton-mile records may necessitate deviation from the established cut-off procedure. Excessive loads caused by pulling stuck drill pipe or running casing, or excess bending imposed by running long strings of tubing may result in the necessity of variation from the predetermined schedule.

If after running one or more lines using the recommended cut-off practice it is found that the line has been retired without having developed excessive wear and wire breakage, the ton-mile interval between cuts may be progressively increased until the maximum safe service is reached. It is only in this way that the full benefit of the additional service possible through a uniform cut-off practice can be realized.

If inspection shows that the rope is wearing badly at the cross-over points on the drum, it may be necessary to increase the number of cuts, thereby reducing the length of cut and the ton-mile interval between cuts.

It will be necessary to compare the cost of cutting and moving the line with the general improvement in rope performance so that an economically sound as well as safe procedure is set up. Too frequent cut-offs would prove uneconomical due to cost and lost time, and too infrequent cut-offs would result in reduced rope life. A proper balance between these extremes should be established.

Courtesy Wickwire Rope, The Colorado Fuel and Iron Corporation.



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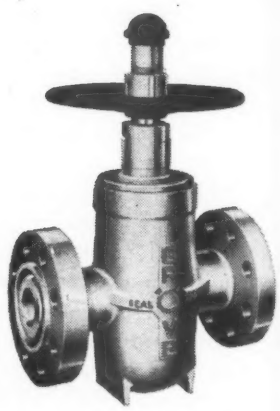

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As there is a growing tendency to go to longer lines, from 3,000 to 3,500 ft in length, a well defined cut-off program becomes more important, in order to take full advantage of longer lines. After the rate of cut-off has been established, it should provide uniform maximum service on these long lines, provided the spare rope on the reel is properly protected from damage, and the tie-down is one that prevents flattening and deformation of the rope.

In Applying Any Cut-Off Practice It is of First Importance That There Be A Direct Relation Between Anticipated Service, The Amount Cut Off Per Cut, and The Ton-Mile Interval Between Cuts. Haphazard cutting-off may result either in good line wasted or operating with an unsafe line.

The cut-off practice must be based on a realistic ton-mile expectancy. To cite an example from actual experience, an investigation was made to determine the reason why it was necessary to cut off and discard about 800 feet from the drum end of a 3,500′ 1¼″ rotary line, due to broken wires in the fast sheaves. It was found that 32 feet had been cut off at average intervals of 2,095 ton-miles of service. Based on the amount of rope in reserve, available for cutting, this cut-off practice, had it been possible to continue at the same rate, would have resulted in a total service of 132,000 ton-miles, or 37 ton miles per foot of line. It is evident that the cut-off procedure, being based on this unrealistic end service, did not move the line through the system at a fast enough rate, and the wires, being subjected to bending for too long a time, broke up through fatigue.

The following example illustrates the application of the above steps outlined in setting up a uniform cut-off practice:

(a) Ton-mile service on a representative 3,500′ 1¼″ 6 × 19 Seale Preformed Improved Plow Steel IWRC rotary line (from previous drilling reports) = 30,000 ton-miles.

(b) Length of line	3500′
Required to string derrick	1450′
Balance available for cutting off	2050′

(c) Estimated Number of Cuts to keep under maximum of 150′ per cut = 14.

Length per cut = 2050′ ÷ 14 = 146′.

(d) Interval between cuts = 30,000 ton-miles (from representative line) ÷ 14 (number of cuts) = 2143 ton-miles.

The cut-off practice is thus established as follows: Cut off 146 feet from the drum end at intervals of 2,143 ton-miles. The ton-mile interval will vary from this somewhat, since the line obviously cannot be cut when making a trip, so that the ton-mile interval nearest to that established should be maintained.

The following illustrates application of the ton-mile practice to a shorter line:

(a) Ton-mile service on a representative 1750′ 1⅛″ 6 × 19 Seale Preformed Improved Plow Steel IWRC Rotary Line = 12,000 ton-miles (from drilling reports).

(b) Length of line	1750′
Required to string derrick	1450′
Balance available for cutting	300′

(c) 300′ ÷ 8 (minimum number of cuts) = 37 ft per cut.

On a 7½ feet circumference drum, this length is over 3½ times the drum circumference, so falls within the established limit.

(d) Interval between cuts = 12,000 Ton-miles (anticipated ton-mile service) ÷ 8 (number of cuts) = 1500 ton-miles.

If the computed length to be cut off is an exact multiple of the drum circumference, successive cuts should be staggered above and below this length to change the point of cross-over on the drum, preventing concentration of wear on the rope.

General Recommendations

1. Check all sheave grooves regularly, particularly before installing a new rotary line. Sheaves should be checked each time the rig is torn down and moved, for at this time sheaves can be most readily replaced or regrooved.

2. The first layer of the rope on the drum should be put on as tightly as possible, for the winding of this layer influences the winding of the layers above.

3. The tie-down should be such that the rope is not crushed or distorted. This is particularly important where a long line is purchased, for this damaged section, due to cutting from the drum end, eventually passes over the sheaves in the crown and traveling blocks, where any deformation may cause failure and loss of a considerable length of line.

4. Wire rope clips, when used, should be attached with the saddle bearing on the loaded side of the line, and the U-bolt on the slack side of the line. Clips attached in an incorrect manner deform the line, resulting in excess wear when this section reaches the sheaves.

Courtesy Wickwire Rope, The Colorado Fuel and Iron Corporation.

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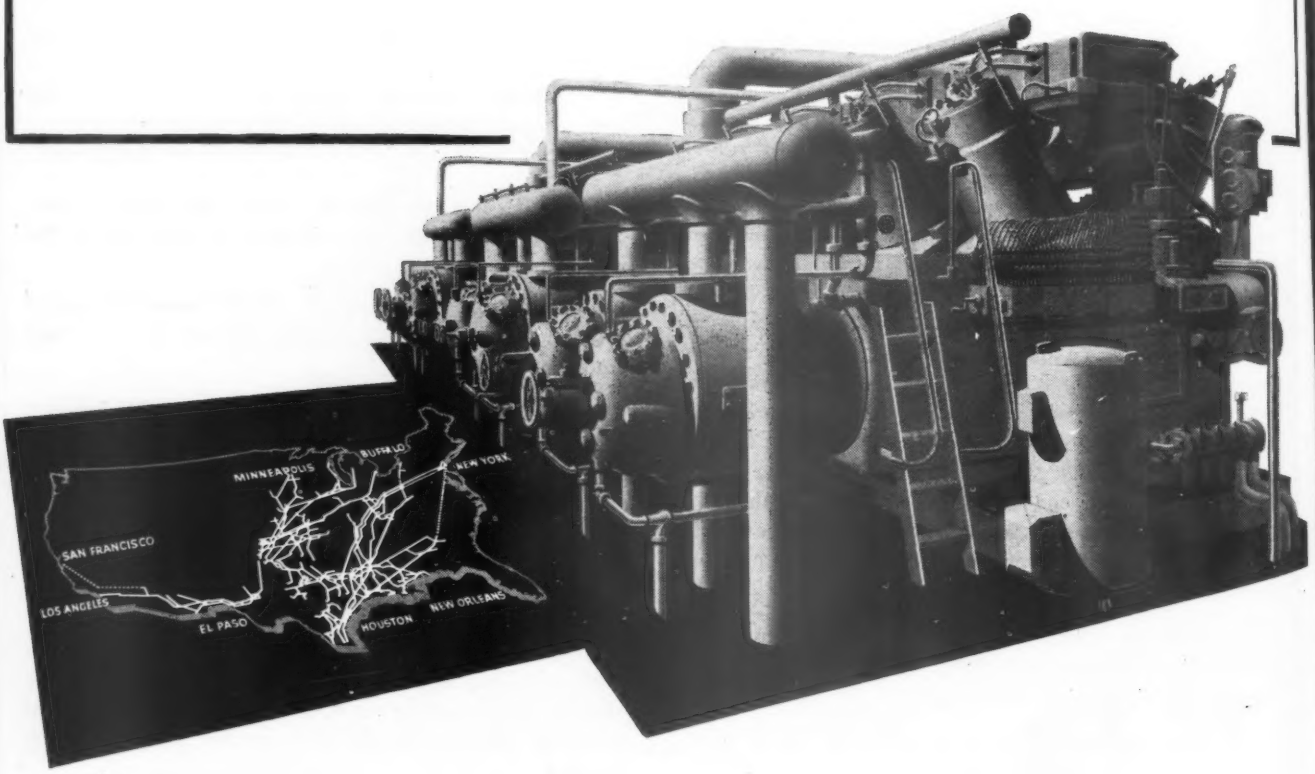

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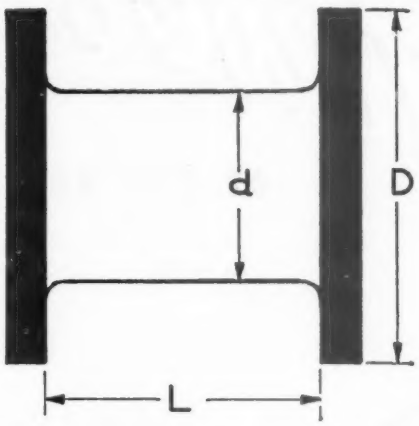
ROPE CAPACITY OF HOISTING DRUM



TO FIND THE WIRE ROPE CAPACITY OF A DRUM

Length of wire rope in feet that a drum will hold = $(D^2—d^2)$ LX

D = Diameter of flange in inches

d = Diameter of drum in inches

L = Inside width of drum in inches

X = Rope Factor—See Table below

Rope Factors

1/8 inch	4.250	1 inch	.0655
1/4 inch	1.018	1 1/8 inch	.0516
3/8 inch	.466	1 1/4 inch	.0418
7/16 inch	.341	1 3/8 inch	.0347
1/2 inch	.262	1 1/2 inch	.0292
9/16 inch	.2064	1 5/8 inch	.0248
5/8 inch	.168	1 3/4 inch	.0214
11/16 inch	.138	1 7/8 inch	.0186
3/4 inch	.116	2 inch	.0164
13/16 inch	.099	2 1/4 inch	.0129
7/8 inch	.085	2 1/2 inch	.0105

APPROXIMATE METALLIC AREAS OF WIRE ROPES

Rope Construction	Metallic area* (square inches)	Efficiency factor (per cent)
6 x 7	.380 d^2	86.0
6 x 17	.385 d^2	82.5
6 x 19 Seale	.395 d^2	82.5
6 x 21 Filler Wire	.395 d^2	82.5
6 x 19 Warrington	.405 d^2	82.5
6 x 25 Filler Wire	.405 d^2	82.5
6 x 37	.400 d^2	80.0
8 x 19	.352 d^2	82.5

Typical Calculations for 1/2" 6 x 7 Mild Plow Steel Wire Rope
B. S. = 7.79 Tons. = 15,580 lbs.

Approximate Metallic Area
= .380 $(1/2)^2$ = .095 sq. in.

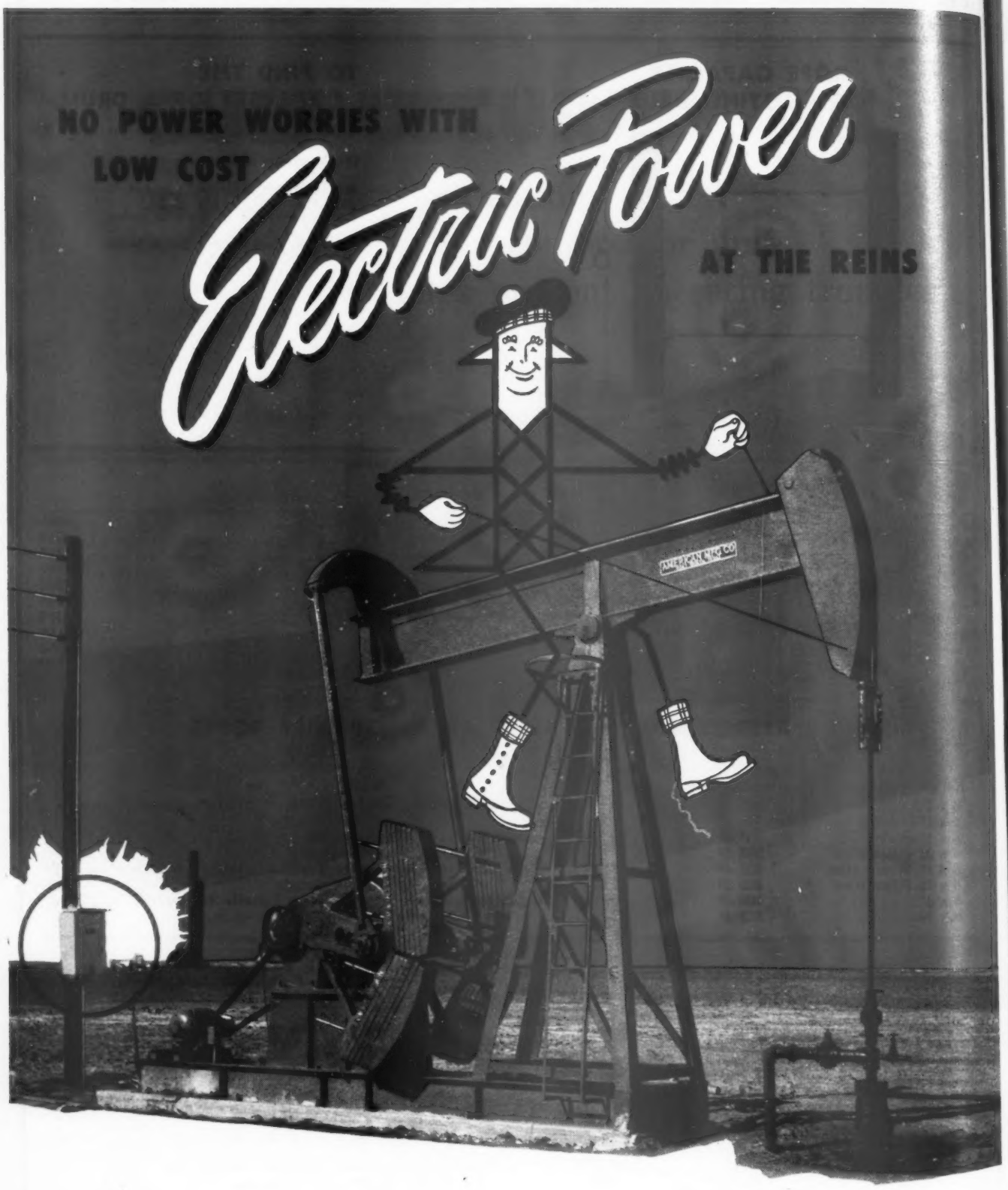
Approximate Aggregate Tensile Strength of Wires in Rope
= 15,580/.86 = 18,116 pounds.

Approximate Individual Wire Tensile Strength
= 18,116/.095 = 190,694 pounds/sq. in.

STRENGTH OF NEW MANILA ROPES

Circumference in inches	Nominal diameter in inches	Minimum tensile strength in pounds	Circumference in inches	Nominal diameter in inches	Minimum tensile strength in pounds
9/16	3/16	420	4	1 5/16	15,000
3/4	1/4	550	4 1/2	1 1/2	18,500
1	5/16	950	5	1 5/8	22,500
1 1/8	3/8	1,275	5 1/2	1 3/4	26,500
1 1/4	7/16	1,750	6	2	31,000
1 3/8	15/32	2,250	6 1/2	2 1/8	36,000
1 1/2	1/2	2,650	7	2 1/4	41,000
1 3/4	9/16	3,450	7 1/2	2 1/2	46,500
2	5/8	4,400	8	2 5/8	52,000
2 1/4	3/4	5,400	8 1/2	2 7/8	58,000
2 1/2	13/16	6,500	9	3	64,000
2 3/4	7/8	7,700	9 1/2	3 1/8	71,000
3	1	9,000	10	3 1/4	77,000
3 1/4	1 1/16	10,500	11	3 1/2	91,000
3 1/2	1 1/8	12,000	12	4	105,000
3 3/4	1 1/4	13,500			

Courtesy Wickwire Rope, The Colorado Fuel and Iron Corporation.



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0.61	1.0083	1.0000	0.9919	0.9840	0.9763	0.9687	0.9614	0.9542	0.9471	0.9402	0.9335	0.9269	0.9204	0.9141
0.62	1.0165	1.0082	1.0000	0.9920	0.9843	0.9766	0.9692	0.9620	0.9549	0.9479	0.9411	0.9345	0.9280	0.9216
0.63	1.0247	1.0163	1.0080	1.0000	0.9922	0.9845	0.9770	0.9697	0.9625	0.9555	0.9489	0.9420	0.9354	0.9290
0.64	1.0328	1.0243	1.0160	1.0079	1.0000	0.9923	0.9847	0.9774	0.9701	0.9631	0.9562	0.9494	0.9428	0.9363
0.65	1.0408	1.0323	1.0239	1.0158	1.0078	1.0000	0.9924	0.9850	0.8777	0.9706	0.9636	0.9568	0.9501	0.9436
0.66	1.0488	1.0402	1.0318	1.0235	1.0155	1.0077	1.0000	0.9925	0.9852	0.9780	0.9710	0.9641	0.9574	0.9508
0.67	1.0567	1.0480	1.0395	1.0313	1.0232	1.0153	1.0075	1.0000	0.9926	0.9854	0.9783	0.9714	.9647	0.9580
0.68	1.0646	1.0585	1.0489	1.0389	1.0308	1.0228	1.0150	1.0074	1.0000	0.9927	0.9856	0.9786	0.9718	0.9651
0.69	1.0724	1.0636	1.0549	1.0465	1.0383	1.0303	1.0225	1.0148	1.0073	1.0000	0.9928	0.9858	0.9789	0.9722
0.70	1.0801	1.0713	1.0626	1.0541	1.0458	1.0377	1.0299	1.0221	1.0146	1.0072	1.0000	0.9929	0.9860	0.9792
0.71	1.0878	1.0789	1.0701	1.0616	1.0533	1.0451	1.0372	1.0294	1.0218	1.0144	1.0071	1.0000	0.9930	0.9862
0.72	1.0954	1.0864	1.0776	1.0690	1.0607	1.0525	1.0445	1.0366	1.0290	1.0215	1.0142	1.0070	1.0000	0.9931
0.73	1.1030	1.0940	1.0851	1.0764	1.0680	1.0597	1.0517	1.0438	1.0361	1.0286	1.0212	1. 140	1.0069	1.0000
0.74	1.1105	1.1014	1.0925	1.0838	1.0753	1.0670	1.0589	1.0509	1.0432	1.0356	1.0282	1.0209	1.0138	1.0068
0.75	1.1180	1.1088	1.0999	1.0911	1.0825	1.0742	1.0660	1.0580	1.0502	1.0426	1.0351	1.0278	1.0206	1.0136
0.76	1.1255	1.1162	1.1072	1.0983	1.0897	1.0813	1.0731	1.0650	1.0572	1.0495	1.0420	1.0346	1.0274	1.0203
0.77	1.1328	1.1235	1.1144	1.1055	1.0969	1.0884	1.0801	1.0720	1.0641	1.0564	1.0488	1.0414	1.0341	1.0270
0.78	1.1402	1.1308	1.1216	1.1127	1.1040	1.0954	1.0871	1.0790	1.0710	1.0632	1.0556	1.0481	1.0408	1.0337
0.79	1.1475	1.1380	1.1288	1.1198	1.1110	1.1024	1.0941	1.0859	1.0779	1.0700	1.0623	1.0548	1.0475	1.0403
0.80	1.1547	1.1452	1.1359	1.1269	1.1180	1.1094	1.1010	1.0927	1.0847	1.0768	1.0690	1.0615	1.0541	1.0469
0.81	1.1619	1.1523	1.1430	1.1339	1.1250	1.1163	1.1078	1.0995	1.0914	1.0835	1.0757	1.0681	1.0607	1.0534
0.82	1.1690	1.1594	1.1500	1.1409	1.1319	1.1232	1.1146	1.1063	1.1081	1.0901	1.0823	1.0477	1.0672	1.0599
0.83	1.1761	1.1665	1.1570	1.1478	1.1388	1.1300	1.1214	1.113)	1.1048	1.0968	1.0889	1.0812	1.0737	1.0663
0.84	1.1832	1.1735	1.1640	1.1547	1.1457	1.1368	1.1282	1.1197	1.1114	1.1034	1.0955	1.0877	1.0801	1.0727
0.85	1.1902	1.1804	1.1709	1.1615	1.1524	1.1435	1.1348	1.1263	1.1180	1.1099	1.1019	1.0942	1.0865	1.0791
0.86	1.1972	1.1874	1.1777	1.1684	1.1592	1.1502	1.1415	1.1329	1.1246	1.1164	1.1084	1.1006	1.0929	1.0854
0.87	1.2042	1.1943	1.1846	1.1751	1.1659	1.1569	1.1481	1.1395	1.1311	1.1229	1.1148	1.1070	1.0992	1.0917
0.88	1.2111	1.2011	1.1914	1.1819	1.1726	1.1635	1.1547	1.1460	1.1376	1.1293	1.1212	1.1133	1.1055	1.0979
0.89	1.2179	1.2079	1.1981	1.1886	1.1793	1.1701	1.1613	1.1525	1.1440	1.1357	1.1276	1.1196	1.1118	1.1042
0.90	1.2247	1.2147	1.2048	1.1952	1.1859	1.1767	1.1677	1.1590	1.1504	1.1421	1.1339	1.1259	1.1180	1.1103
0.91	1.2315	1.2211	1.2115	1.2018	1.1924	1.1832	1.1742	1.1654	1.1568	1.1484	1.1402	1.1321	1.1242	1.1165
0.92	1.2383	1.2282	1.2181	1.2084	1.1990	1.1897	1.1807	1.1718	1.1632	1.1547	1.1464	1.1383	1.1304	1.1226
0.93	1.2450	1.2348	1.2248	1.2150	1.2055	1.1961	1.1871	1.1782	1.1695	1.1610	1.1526	1.1445	1.1365	1.1287
0.94	1.2517	1.2414	1.2313	1.2215	1.2119	1.2026	1.1934	1.1845	1.1757	1.1672	1.1588	1.1506	1.1426	1.1348
0.95	1.2583	1.2480	1.2378	1.2280	1.2184	1.2089	1.1998	1.1908	1.1820	1.1734	1.1650	1.1567	1.1487	1.1408
0.96	1.2649	1.2545	1.2443	1.2344	1.2248	1.2153	1.2061	1.1970	1.1882	1.1795	1.1711	1.1628	1.1547	1.1468
0.97	1.2715	1.2610	1.2508	1.2408	1.2311	1.2216	1.2123	1.2032	1.1944	1.1857	1.1772	1.1689	1.1607	1.1527
0.98	1.2780	1.2675	1.2572	1.2472	1.2374	1.2279	1.2185	1.2094	1.2005	1.1918	1.1832	1.1749	1.1667	1.1586
0.99	1.2845	1.2740	1.2636	1.2536	1.2437	1.2341	1.2248	1.2156	1.2066	1.1978	1.1892	1.1808	1.1726	1.1645
1.00	1.2910	1.2804	1.2700	1.2599	1.2500	1.2403	1.2309	1.2217	1.2127	1.2039	1.1952	1.1868	1.1785	1.1704

FORMULA: $\frac{\sqrt{\text{old gravity}}}{\sqrt{\text{new gravity}}}$ = Multiplier (correction factor)

EXAMPLE OF COMPUTATION: To correct from a gravity of 0.60 to 0.70:

$$\frac{\sqrt{0.600}}{\sqrt{0.700}} = \frac{0.7746}{0.8367} = 0.9258 \text{ (as shown above on 0.60 line under 0.70)}$$

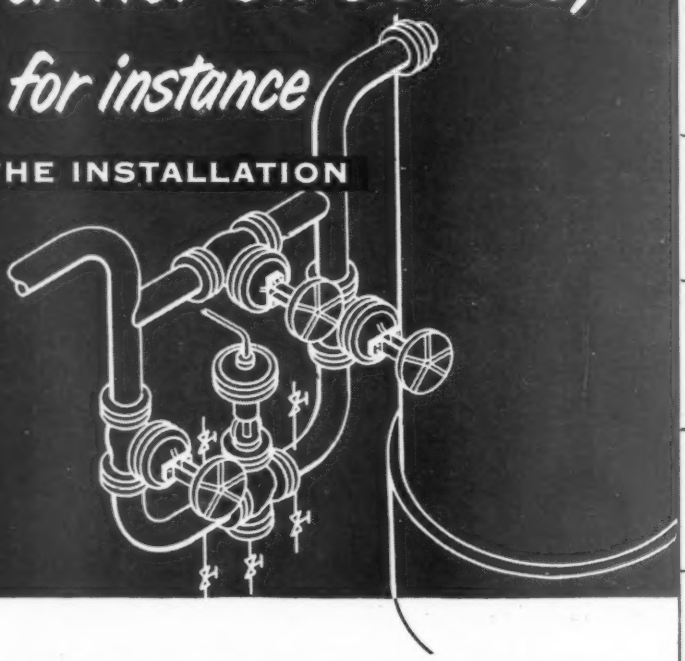
NOTE: The multipliers in these tables may be used in conjunction with orifice meter coefficients such as *The Petroleum Engineer's* table P 683.320.3, entitled "One Hour Coefficient at Various Pressure Bases," published in June, 1943. Multiplication of any of those coefficients (based on 0.60 gravity gas) by the multiplier in the first line above that corresponds to the actual gravity of the gas being measured through an orifice plate will properly correct the coefficient for use in calculating the actual volume.

EXAMPLE OF USE: The one hour coefficient for a 4 x ¼ in. plate with flange connections in a 4.026 I.D. pipe = 16.6 (for 14.4 lb. plus 4 oz. abs. pressure base, 0.60 gravity, and 60°F. temperature).

Then, for correction from 0.60 to 0.70 gravity, multiply 16.6 by 0.9258 (under 0.70 and on the 0.60 line above) = 15.368 (corrected one hour coefficient.)

You Can Measure this Valve's Quality on Hot Oil Service, for instance

THE INSTALLATION



In a leading lube oil plant on the Gulf Coast, using Crane Steel Valves on hot oil extraction lines from tower in Duo-Sol unit. Working pressure 100 psi at 850 degrees F.

VALVE SERVICE RATINGS

SUITABILITY: Couldn't be better

FEATURES: Expelloy trim

MAINTENANCE COST: Routine service only

SERVICE LIFE: No efficiency loss since 1951

OPERATING RESULTS: Safe, dependable control

AVAILABILITY: Catalog item — No. 47X

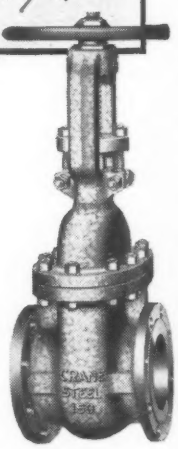
THE CASE HISTORY

Valves formerly used here were identical in design and appearance with their Crane replacements. But the similarity ended there. For they gave continual trouble in this round-the-clock process. Sticking discs made them extremely difficult to operate. They failed to hold tight on closure. Their replacement became mandatory for efficient operation.

It's been a different story since Crane 47X steel gates were installed almost 2 years ago. No more sticking of discs . . . no leakage anywhere . . . and with only routine maintenance.

THE VALVE

Work horse of the petroleum industry—Crane 150-pound steel gates—with exceptional performance assured by Crane quality design . . . Crane metallurgy . . . and the high adaptability of Crane Exelloy trim for oil and oil vapor services. Sizes 2 to 24 in.; screwed, flanged, welding ends. See your Crane Catalog or Crane Representative.



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Branches and Wholesalers Serving All Industrial Areas

VALVES · FITTINGS · PIPE · PLUMBING · HEATING

SPECIFIC GRAVITY CORRECTION FACTORS FOR ORIFICE METERS

From	To 0.74	0.75	0.76	0.77	0.78	0.79	0.80	0.81	0.82	0.83	0.84	0.85	0.86	0.87
0.60	0.9005	0.8944	0.8885	0.8827	0.8771	0.8715	0.8660	0.8607	0.8554	0.8502	0.8452	0.8402	0.8353	0.8305
0.61	0.9079	0.9018	0.8959	.8901	0.8843	0.8787	0.8732	0.8678	0.8625	0.8573	0.8522	0.8471	0.8422	0.8373
0.62	0.9153	0.9092	0.9032	0.8973	0.8916	0.8859	0.8803	0.8749	0.8695	0.8643	0.8591	0.8541	0.8491	0.8442
0.63	0.9227	0.9165	0.9105	0.9045	0.8987	0.8930	0.8874	0.8819	0.8765	0.8712	0.8660	0.8609	0.8559	0.8510
0.64	0.9300	0.9238	0.9177	0.9117	0.9058	0.9001	0.8944	0.8889	0.8835	0.8781	0.8729	0.8677	0.8627	0.8577
0.65	0.9372	0.9309	0.9248	0.9188	0.9120	0.9071	0.9014	0.8958	0.8903	0.8850	0.8797	0.8744	0.8694	0.8644
0.66	0.9444	0.9381	0.9319	0.9258	0.9199	0.9140	0.9083	0.9027	0.8971	0.8917	0.8864	0.8812	0.8760	0.8710
0.67	0.9515	0.9452	0.9389	0.9328	0.9268	0.9209	0.9152	0.9095	0.9039	0.8985	0.8931	0.8878	0.8827	0.8776
0.68	0.9586	0.9522	0.9459	0.9397	0.9337	0.9278	0.9220	0.9162	0.9106	0.9051	0.8997	0.8944	0.8892	0.8841
0.69	0.9656	0.9592	0.9528	0.9466	0.9405	0.9346	0.9287	0.9230	0.9173	0.9118	0.9063	0.9010	0.8957	0.8906
0.70	0.9726	0.9661	0.9597	0.9535	0.9473	0.9413	0.9354	0.9296	0.9239	0.9184	0.9128	0.9075	0.9022	0.8970
0.71	0.9795	0.9730	0.9665	0.9602	0.9541	0.9480	0.9421	0.9362	0.9305	0.9249	0.9194	0.9139	.9086	.9034
0.72	0.9864	0.9798	0.9733	0.9670	0.9608	0.9547	0.9487	0.9428	0.9370	0.9314	0.9258	0.9204	0.9150	0.9097
0.73	0.9932	0.9866	0.9801	0.9737	0.9674	0.9613	0.9552	0.9493	0.9435	0.9378	0.9322	0.9267	0.9213	0.9160
0.74	1.0000	0.9933	0.9868	0.9803	0.9740	0.9678	0.9618	0.9558	0.9500	0.9442	0.9386	0.9331	0.9276	0.9223
0.75	1.0067	1.0000	0.9934	0.9869	0.9806	0.9744	0.9682	0.9623	0.9564	0.9506	0.9449	0.9393	0.9339	0.9285
0.76	1.0134	1.0066	1.0000	0.9935	0.9871	0.9808	0.9747	0.9686	0.9627	0.9569	0.9512	0.9456	0.9401	0.9346
0.77	1.0201	1.0132	1.0066	1.0000	0.9936	0.9873	0.9811	0.9750	0.9690	0.9632	0.9574	0.9518	0.9462	0.9408
0.78	1.0267	1.0198	1.0131	1.0065	1.0000	0.9937	0.9874	0.9813	0.9753	0.9694	0.9636	0.9579	0.9 23	0.9469
0.79	1.0332	1.0263	1.0195	1.0129	1.0064	1 0000	0.9937	0.9876	0.9815	0.9756	0.9697	0.9641	0.9584	0.9529
0.80	1.0398	1 0328	1.0260	1.0193	1.0127	1 0063	1.0000	0.9938	0.9877	0.9818	0.9759	0.9701	0.9645	0.9589
0.81	1.0462	1.0392	1.0324	1.0256	1.0190	1.0126	1.0062	1.0000	0.9939	0.98 9	0.9820	0.9762	0.9705	0.9649
0.82	1.0527	1.0456	1.0387	1.0320	1.0253	1.0188	1.0124	1. 062	1.0000	0.9940	0.9880	0.9822	0.9765	0.9708
0.83	1.0591	1.0520	1.0450	1.0382	1.0315	1.0250	1.0186	1.0123	1.0061	1.0000	0.9940	0.9882	0.9824	0.9767
0.84	1.0654	1.0583	1.0513	1.0445	1.0377	1.0312	1.0247	1.0184	1.0121	1.0060	1.0000	0.9941	0.9883	0.9826
0.85	1.0717	1.0646	1.0575	1.0507	1.0439	1.0373	1.0308	1.0244	1.0181	1.0120	1.0059	1.0000	0.9942	0.9884
0.86	1.0780	1.0708	1.0638	1.0568	1.0500	1.0434	1.0368	1.0304	1.0241	1.0179	1.0118	1.0059	1 0000	0.9942
0.87	1.0843	1.0770	1.0699	1.0630	1.0561	1.0494	1.0428	1.0364	1.0300	1.0238	1.0177	1.0117	1 C058	1.C000
0.88	1.0905	1.0832	1.0761	1.0690	1.0622	1.0554	1.0488	1.0423	1.0359	1.0297	1.0235	1.0175	1.0116	1.0057
0.89	1.0967	1.0893	1.0822	1.0751	1.0682	1.0614	1.0547	1.0482	1.0418	1.0355	1.0293	1.0233	1.0173	1.0114
0.90	1.1028	1.0954	1.0882	1.0811	1.0742	1.0673	1.0607	1.0541	1.0476	1.0413	1.0351	1.0290	1.0230	1.0171
0.91	1.1089	1.1015	1.0942	1.0871	1.0801	1.0733	1.0665	1.0599	1.0534	1.0471	1.0408	1.0347	1.0287	1.0227
0.92	1.1150	1.1075	1.1002	1.0931	1.0860	1.0791	1.0724	1.0657	1.0592	1.0528	1.0465	1.0404	1 0343	1.0283
0.93	1.1211	1.1136	1.1062	1.0990	1.0919	1.0850	1.0782	1.0715	1.0650	1.0595	1. 522	1.0460	1.0399	1.0339
0.94	1.1271	1.1195	1.1121	1.1049	1.0978	1.0908	1.0840	1.0773	1.0707	1.0642	1.0578	1.0516	1.0455	1.0395
0.95	1.1330	1.1255	1.1180	1.1107	1.1036	1.0966	1.0897	1.0830	1.0764	1. 699	1.0635	1.0571	1.0510	1.0450
0.96	1.1390	1.1314	1.1239	1.1166	1.1094	1.1024	1.0954	1.0887	1.0820	1.0755	1.0690	1.0627	1.0565	1.0505
0.97	1.1449	1.1372	1.1297	1.1224	1.1152	1.1081	1.1011	1.0943	1.0876	1.0811	1.0746	1.0683	1.0620	1.0559
0.98	1.1508	1.1431	1.1356	1.1281	1.1209	1.1138	1.1068	1.0999	1.0932	1.0866	1.0801	1.0738	1.0675	1.0613
0.99	1.1567	1.1489	1.1413	1.1339	1.1266	1.1195	1.1124	1.1055	1.0988	1.0921	1.0856	1.0792	1.0729	1.0667
1.00	1.1625	1.1547	1.1471	1.1396	1.1323	1.1251	1.1180	1.1111	1.1043	1.0976	1.0911	1.0847	1.0783	1.0721

FORMULA: $\frac{\sqrt{\text{old gravity}}}{\sqrt{\text{new gravity}}}$ = Multiplier (correction factor)

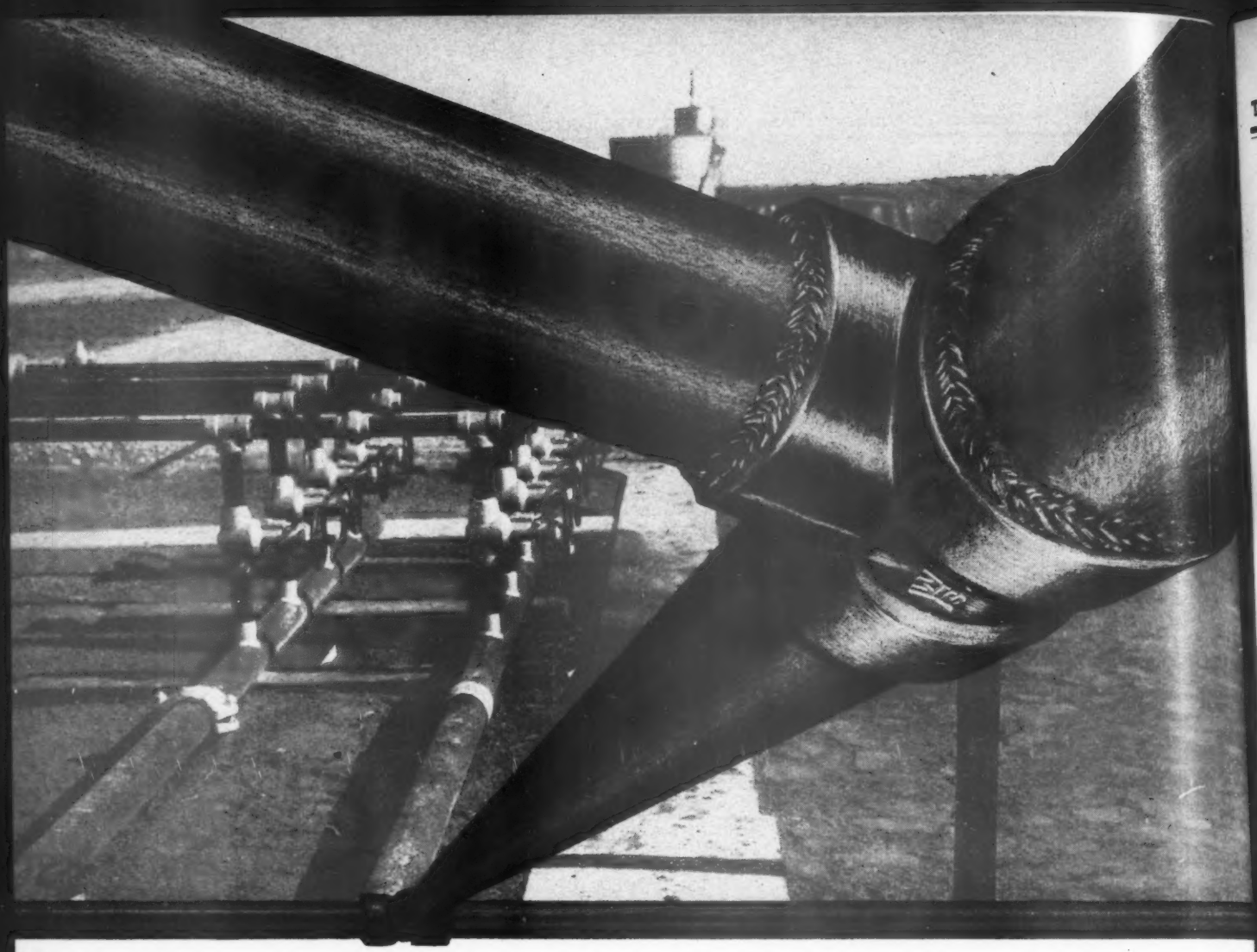
EXAMPLE OF COMPUTATION: To correct from a gravity of 0.60 to 0.80:

$$\frac{\sqrt{0.600}}{\sqrt{0.800}} = \frac{0.7746}{0.8944} = 0.8660 \text{ (as shown above on 0.60 line under 0.80)}$$

NOTE: The multipliers in these tables may be used in conjunction with orifice meter coefficients such as *The Petroleum Engineer's* table P 683.320.3, entitled "One Hour Coefficient at Various Pressure Bases," published in June, 1943. Multiplication of any of those coefficients (based on 0.60 gravity gas) by the multiplier in the first line above that corresponds to the actual gravity of the gas being measured through an orifice plate will properly correct the coefficient for use in calculating the actual volume.

EXAMPLE OF USE: The one hour coefficient for a 4 x ¼-in. plate with flange connections in a 4.026 I.D. pipe = 16.6 (for 14.4 lb. plus 4 oz. absolute pressure base, 0.60 gravity, and 60°F. temperature).

Then, for correction from 0.60 to 0.80 gravity, multiply 16.6 by 0.8660 (under 0.80 and on the 0.60 line above) = 14.375 (corrected one hour coefficient).



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SPECIFIC GRAVITY CORRECTION FACTORS FOR ORIFICE METERS

From \ To	0.88	0.89	0.90	0.91	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99	1.00
0.60	0.8257	0.8211	0.8165	0.8120	0.8076	0.8032	0.7989	0.7947	0.7906	0.7865	0.7825	0.7785	0.7746
0.61	0.8326	0.8279	0.8233	0.8187	0.8143	0.8099	0.8056	0.8013	0.7971	0.7930	0.7889	0.7850	0.7810
0.62	0.8394	0.8346	0.8300	0.8254	0.8209	0.8165	0.8121	0.8079	0.8036	0.7995	0.7954	0.7914	0.7874
0.63	0.8461	0.8414	0.8367	0.8321	0.8275	0.8231	0.8187	0.8143	0.8101	0.8059	0.8018	0.7977	0.7937
0.64	0.8528	0.8480	0.8433	0.8386	0.8341	0.8296	0.8251	0.8208	0.8165	0.8123	0.8081	0.8040	0.8000
0.65	0.8594	0.8546	0.8498	0.8452	0.8405	0.8360	0.8316	0.8272	0.8229	0.8186	0.8144	0.8103	0.8062
0.66	0.8660	0.8611	0.8564	0.8516	0.8470	0.8424	0.8379	0.8335	0.8291	0.8249	0.8206	0.8165	0.8124
0.67	0.8726	0.8676	0.8628	0.8581	0.8534	0.8488	0.8443	0.8398	0.8354	0.8311	0.8268	0.8227	0.8185
0.68	0.8791	0.8741	0.8692	0.8644	0.8597	0.8551	0.8505	0.8460	0.8416	0.8373	0.8330	0.8288	0.8246
0.69	0.8855	0.8805	0.8756	0.8708	0.8660	0.8613	0.8568	0.8523	0.8478	0.8434	0.8391	0.8348	0.8307
0.70	0.8919	0.8869	0.8819	0.8771	0.8723	0.8676	0.8529	0.8584	0.8539	0.8495	0.8452	0.8409	0.8367
0.71	0.8982	0.8932	0.8882	0.8833	0.8785	0.8737	0.8691	0.8645	0.8600	0.8555	0.8512	0.8469	0.8426
0.72	0.9045	0.8994	0.8944	0.8895	0.8847	0.8799	0.8752	0.8706	0.8660	0.8615	0.8571	0.8528	0.8485
0.73	0.9108	0.9057	0.900	0.8957	0.8908	0.8860	0.8812	0.8766	0.8720	0.8675	0.8631	0.8587	0.8544
0.74	0.9170	0.9118	0.9068	0.9018	0.8968	0.8920	0.8873	0.8826	0.8780	0.8734	0.8690	0.8646	0.8602
0.75	0.9232	0.9180	0.9129	0.9078	0.9029	0.8980	0.8932	0.8885	0.8 39	0.8793	0.8748	0.8704	0.8660
0.76	0.9293	0.9241	0.9189	0.91 9	0.9089	0.9040	0.8992	0.8944	0.8898	0.8852	0.8806	0.8762	0.8718
0.77	0.9354	0.9301	0.9250	0.9199	0.9149	0.9099	0.9051	0.9003	0.8956	0.8910	0.8864	0.8819	0.8775
0.78	0.9415	0.9362	0.9310	0.9258	0.9208	0.9158	0.9109	0.9061	0.9014	0.8967	0.8921	0.8876	0.8832
0.79	0.9475	0.9421	0.9369	0.9317	0.9267	0.9217	0.9167	0.9119	0.9071	0.9025	0.8978	0.8933	0.8888
0.80	0.9535	0.9481	0.9428	0.9376	0.9325	0.9275	0.9225	0.9177	0.9129	0.9082	0.9035	0.8989	0.8944
0.81	0.9594	0.9540	0.9487	0.9435	0.9383	0.9333	0.9283	0.9234	0.9186	0.9138	0.9091	0.9045	0.9000
0.82	0.9653	0.9599	0.9545	0.9493	0.9441	0.9390	0.9340	0.9291	0.9242	0.9194	0.9147	0.9101	0.9055
0.83	0.9712	0.9657	0.9603	0.9550	0.9498	0.9447	0.9397	0.9347	0.9298	0.9250	0.9203	0.9156	0.9110
0.84	0.9770	0.9715	0.9661	0.9608	0.9553	0.9504	0.9453	0.9403	0.9354	0.9306	0.9258	0.9211	0.9165
0.85	0.982	0.9773	0.9718	0.9665	0.9612	0.9560	0.9509	0.9459	0.9410	0.9361	0.9313	0.9266	0.9220
0.86	0.9886	0.9830	0.9775	0.9721	0.9668	0.9616	0.9565	0.9515	0.9465	0.9416	0.9368	0.9320	0.9274
0.87	0.9943	0.9887	0.9832	0.9778	0.9724	0.9672	0.9620	0.9570	0.9520	0.9470	0.9422	0.9374	0.9327
0.88	1.0000	0.9944	0.9888	0.9834	0.9780	0.9727	0.9676	0.9624	0.9574	0.9525	0.9476	0.9428	0.9381
0.89	1.0057	1.0000	0.9944	0.9890	0.9836	0.9783	0.9730	0.9679	0.9628	0.9579	0.9530	0.9482	0.9434
0.90	1.0113	1.0056	1.0000	0.9945	0.9891	0.9837	0.9785	0.9733	0.9682	0.9632	0.9583	0.9535	0.9487
0.91	1.0169	1.0112	1.0055	1.0000	0.9945	0.9892	0.9839	0.9787	0.9736	0.9686	0.9636	0.9587	0.9539
0.92	1.0225	1.0167	1.0111	1.0055	1.0000	0.9946	0.9893	0.9841	0.9789	0.9739	0.9689	0.9640	0.9592
0.93	1.0280	1.0222	1.0165	1.0109	1.0054	1.0000	0.9947	0.9894	0.9843	0.9792	0.9742	0.9692	0.9644
0.94	1.0335	1.0 77	1.0220	1.0164	1.0108	1.0054	1.0000	0.9947	0.9895	0.9844	0.9794	0.9744	0.9695
0.95	1.0390	1.0332	1.0274	1.0217	1.0162	1.0107	1.0053	1.0000	0.9948	0.9896	0.9846	0.9796	0.9747
0.96	1.0445	1.0386	1.0328	1.0271	1.0215	1.0160	1.0106	1.0053	1.0000	0.9948	0.9897	0.9847	0.9798
0.97	1.0499	1.0440	1.0382	1.0324	1.0268	1.0213	1.0158	1.0105	1.0052	1.0000	0.9949	0.9898	0.9849
0.98	1.0553	1.0493	1.0435	1.0377	1.0321	1.0265	1.0211	1.0157	1.0104	1.0051	1.0000	0.9949	0.9900
0.99	1.0607	1.0547	1.0488	1.0430	1.0373	1.0318	1.0262	1.0208	1.0155	1.0103	1.0051	1.0000	0.9950
1.00	1.0660	1.0600	1.0541	1.0483	1.0426	1.0369	1.0314	1.0260	1.0206	1.0153	1.0102	1.0050	1.0000

FORMULA: $\dfrac{\sqrt{\text{old gravity}}}{\sqrt{\text{new gravity}}}$ = Multiplier (correction factor)

EXAMPLE OF COMPUTATION: To correct from a gravity of 0.60 to 0.90:

$$\frac{\sqrt{0.600}}{\sqrt{0.700}} = \frac{0.7746}{0.9487} = 0.8165$$ (as shown above on 0.60 line under 0.90)

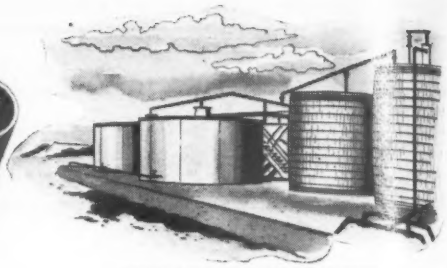
NOTE: The multipliers in these tables may be used in conjunction with orifice meter coefficients such as *The Petroleum Engineer's* table P 683.320.3, entitled "One Hour Coefficient at Various Pressure Bases," published in June, 1943. Multiplication of any of those coefficients (based on 0.60 gravity gas) by the multiplier in the first line above that corresponds to the actual gravity of the gas being measured through an orifice plate will properly correct the coefficient for use in calculating the actual volume.

EXAMPLE OF USE: The one hour coefficient for a 4 x ¼ in. plate with flange connections in a 4.026 I.D. pipe = 16.6 (for 14.4 lb. plus 4 oz. absolute pressure base, 0.60 gravity, and 60°F. temperature).

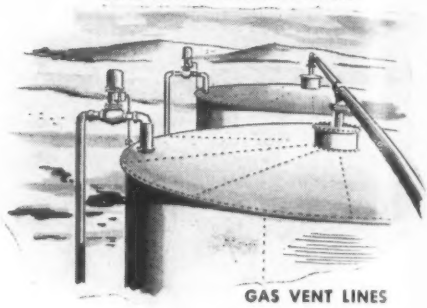
Then, for correction from 0.60 to 0.90 gravity, multiply 16.6 by 0.8165 (under 0.90 and on the 0.60 line above) = 13.554 (corrected one hour coefficient).

*Only Carlon**

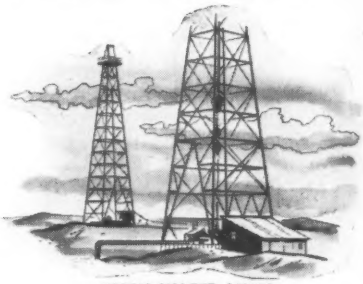
FOR OIL COUNTRY PIPING



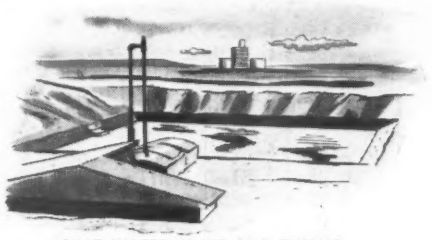
LEAD AND GATHERING LINES



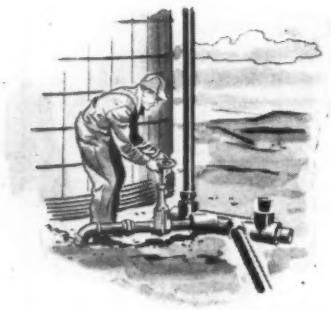
GAS VENT LINES



FRESH WATER LINES



SALT WATER LINES AND TUBING



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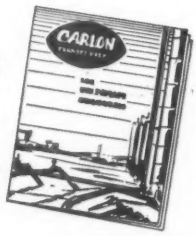

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RELATIVE HUMIDITY AND PRESSURE OF SATURATED WATER VAPOR

Wet bulb reading, deg F.	Pressure of saturated vapor		(t—t'), difference between wet and dry bulb temperatures, deg. F.																		
	in. of Hg	lb. per sq. in.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	0.03773	0.01853	68	38	12																	
1	.03975	.01963	69	41	15																	
2	.04186	.02056	70	43	19																	
3	.04409	.02166	71	46	22	1																
4	.04675	.02282	73	48	25	5																
5	0.04886	0.02400	74	50	28	9																
6	.05144	.02527	75	52	31	12																
7	.05412	.02658	76	54	34	16																
8	.05692	.02796	77	56	37	19	3															
9	.05988	.02941	78	58	39	22	7															
10	0.06295	0.03092	79	59	41	25	10															
11	.06618	.03251	79	61	44	28	14															
12	.06958	.03418	80	62	46	31	17	4														
13	.07309	.03590	81	64	48	33	20	8														
14	.07677	.03771	82	65	49	35	23	11														
15	0.08067	0.03963	82	66	51	38	25	14	4													
16	.08469	.04160	83	67	53	40	28	17	7													
17	.08895	.04369	84	68	55	42	30	20	10	1												
18	.09337	.04586	84	70	56	44	33	22	13	4												
19	.09797	.04812	85	71	58	46	35	25	16	7												
20	0.1028	0.05050	85	72	59	47	37	27	18	10	3											
21	.1078	.05295	86	72	60	49	39	29	21	13	6											
22	.1132	.05560	86	73	62	51	41	32	23	16	8	2										
23	.1186	.05826	87	74	63	52	43	34	26	18	11	5										
24	.1244	.06111	87	75	64	54	44	36	28	20	14	8	2									
25	0.1304	0.06405	87	76	65	55	46	37	30	23	16	10	5									
26	.1366	.06710	88	76	66	56	47	39	32	25	19	13	7	2								
27	.1432	.07034	88	77	67	58	49	41	34	27	21	15	10	5	1							
28	.1500	.07368	88	78	68	59	51	43	36	29	23	17	12	7	3							
29	.1571	.07717	89	78	69	60	52	45	38	31	25	20	15	10	5	1						
30	0.1645	0.08080	89	79	70	62	54	46	40	33	27	22	17	12	8	4						
31	.1722	.08458	89	80	71	63	55	48	42	35	29	24	19	14	10	6	2					
32	.1803	.08856	90	81	72	64	57	50	43	37	31	26	21	16	12	8	5	1				
33	.1879	.09230	90	81	73	65	58	51	45	39	33	28	23	18	14	10	7	3	0			
34	.1957	.09610	90	82	74	66	59	52	76	40	35	30	25	20	16	12	9	5	2			
35	0.2036	0.1000	91	83	75	67	60	54	47	42	36	31	26	22	18	14	10	7	4	1		
36	.2120	.1041	91	83	75	68	61	55	48	43	38	32	28	23	19	16	12	9	6	3	0	
37	.2205	.1083	91	83	75	69	62	55	49	44	39	34	29	25	21	17	14	10	8	5	2	
38	.2293	.1126	92	83	76	69	63	56	51	45	40	35	31	27	23	19	16	12	9	7	4	1
39	.2384	.1171	92	84	77	70	63	57	52	47	41	36	32	28	24	20	17	14	11	8	6	3
40	0.2478	0.1217	92	84	77	70	64	58	53	48	43	38	34	30	26	22	19	16	13	11	8	6
41	.2576	.1265	92	85	78	71	65	59	54	48	44	39	35	31	27	23	20	17	14	12	9	7
42	.2677	.1315	92	85	78	72	66	60	54	49	45	40	36	32	28	25	22	18	16	13	10	8
43	.2783	.1367	93	85	79	72	66	61	55	50	46	41	37	33	30	26	23	20	17	14	12	10
44	.2891	.1420	93	86	79	73	67	61	56	51	47	42	38	34	31	27	24	21	18	16	13	11
45	0.3003	0.1475	93	86	79	73	68	62	57	52	48	43	39	35	32	29	26	22	20	17	15	12
46	.3119	.1532	93	86	80	74	68	63	58	53	49	44	40	37	33	30	27	24	21	18	16	14
47	.3239	.1591	93	86	80	75	69	63	59	54	50	45	41	38	34	31	28	25	22	20	17	15
48	.3364	.1652	93	87	81	75	69	64	59	55	50	46	42	39	35	32	29	26	24	21	19	16
49	.3492	.1715	93	87	81	75	70	65	60	55	51	47	43	40	36	33	30	27	25	22	20	18
50	0.3624	0.1780	94	87	81	76	70	65	61	56	52	48	44	41	37	34	31	29	26	23	21	19
51	.3763	.1848	94	87	82	76	71	66	61	57	53	49	45	42	38	35	32	30	27	24	22	20
52	.3905	.1918	94	88	82	76	71	66	62	58	54	50	46	43	39	36	33	31	28	25	23	21
53	.4050	.1989	94	88	82	77	72	67	63	58	54	50	47	44	40	37	34	32	29	27	24	22
54	.4200	.2063	94	88	83	77	72	68	63	59	55	51	48	44	41	38	35	33	30	28	25	23
55	0.4357	0.2140	94	88	83	78	73	68	64	60	56	52	48	45	42	39	36	33	31	29	26	24
56	.4518	.2219	94	88	83	78	73	69	64	60	56	53	49	46	43	40	37	34	32	29	27	25
57	.4683	.2300	94	89	83	78	74	69	65	61	57	53	50	47	44	41	38	35	33	30	28	26
58	.4854	.2384	94	89	84	79	74	70	66	61	58	54	51	48	45	42	39	36	34	31	29	27
59	.5031	.2471	94	89	84	79	74	70	66	62	58	55	51	48	45	42	39	37	34	32	30	28

This Table is based on a barometric pressure of 30 in. Hg. Values are computed by formula:*

$$\text{Relative humidity, percent} = \frac{p' - [(B - p') \times 1.016(t - t')/(2800 - 1.3t')]}{p} \times 100$$

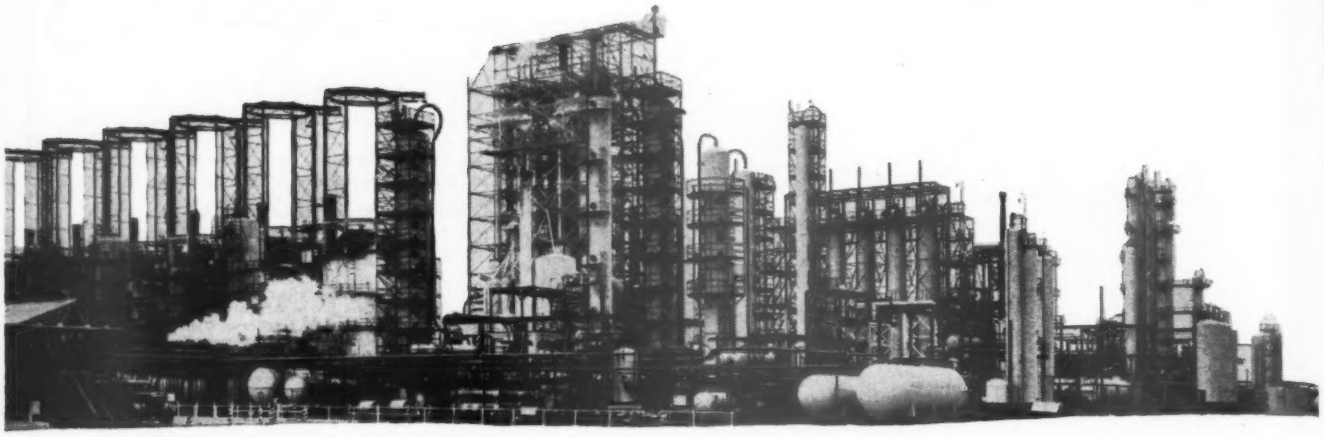
t = dry-bulb temperature
t' = wet-bulb temperature
p = vapor pressure corresponding to t
p' = vapor pressure corresponding to t'
B = barometric pressure
1.016 = factor to correct for mean radiation loss of sling psychrometer

NOTE: If stationary-type psychrometer is used, wet bulb should be exposed to air current having a velocity of not less than 14 ft. per sec.

*Formula developed by W. H. Carrier, *Trans. A.S.M.E.*, vol. 33, p. 1005.

†This table may be filed under P 207. if preferred.

Problem: Scheduling a 38,383,000 barrel refinery program one full year in advance



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RELATIVE HUMIDITY AND PRESSURE OF SATURATED WATER VAPOR

Wet bulb reading deg F	Pressure of saturated vapor		(t −t'), difference between wet and dry bulb temperatures deg. F																			
	in. of Hg	lb per sq. in	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
60	0.52142	0.2561	94	89	84	80	75	71	67	63	59	56	52	49	46	43	41	38	36	34	31	29
61	.54035	.2654	95	89	84	80	75	71	67	63	60	56	53	50	47	44	42	39	37	34	32	30
62	.55970	.2749	95	89	85	80	76	72	68	64	60	57	54	51	48	45	42	40	37	35	33	31
63	.57985	.2848	95	90	85	80	76	72	68	64	61	57	54	51	48	46	43	40	38	36	34	32
64	60042	.2949	95	90	85	81	77	72	68	65	61	58	55	52	49	46	44	41	39	37	34	32
65	0.62179	0.3054	95	90	85	81	77	73	69	65	62	59	55	52	50	47	44	42	40	37	35	33
66	.64378	.3162	95	90	86	81	77	73	69	66	62	59	56	53	50	47	45	42	40	38	36	34
67	.66638	.3273	95	90	86	81	77	73	70	66	63	59	56	53	51	48	45	43	41	38	36	34
68	.68980	.3388	95	90	86	82	77	74	70	66	63	60	57	54	51	48	46	43	41	39	37	35
69	.71382	.3506	95	90	86	82	78	74	70	67	63	60	57	54	52	49	46	44	42	40	38	36
70	0.73866	0.3628	95	91	86	82	78	74	71	67	64	61	58	55	52	49	47	45	42	40	39	36
71	.76431	.3754	95	91	86	82	78	74	71	68	64	61	58	55	53	50	47	45	43	41	39	37
72	.79058	.3883	95	91	87	82	78	75	71	68	65	61	59	56	53	50	48	46	43	41	40	37
73	.81766	.4016	95	91	87	83	79	75	72	68	65	62	59	56	54	51	49	46	44	42	40	38
74	.84555	.4153	95	91	87	83	79	75	72	69	65	62	59	57	54	52	49	47	45	42	41	39
75	0.87448	0.4295	95	91	87	83	79	76	72	69	66	63	60	57	55	52	50	47	45	43	42	39
76	.90398	.4440	95	91	87	83	79	76	73	69	66	63	60	58	55	53	50	48	46	44	42	40
77	.93452	.4590	95	91	87	83	80	76	73	70	67	64	61	58	56	53	51	48	46	44	42	40
78	.96588	.4744	96	91	87	84	80	77	73	70	67	64	61	59	56	54	51	49	47	45	43	41
79	.99825	4903	96	92	88	84	80	77	74	70	67	65	62	59	57	54	52	50	47	45	44	42
80	1.0316	0.5067	96	92	88	84	81	77	74	71	68	65	62	60	57	55	52	50	48	46	44	42
81	1.0661	.5236	96	92	88	84	81	77	74	71	68	65	63	60	57	55	53	50	48	46	44	43
82	1.1013	.5409	96	92	88	84	81	78	74	71	68	65	63	60	58	55	53	51	49	47	45	43
83	1.1377	.5588	96	92	88	85	81	78	75	72	69	66	63	60	58	56	53	51	49	47	45	43
84	1.1752	5772	96	92	88	85	81	78	75	72	69	66	63	61	58	56	54	52	50	47	46	44
85	1.2135	0.5960	96	92	88	85	81	78	75	72	69	66	64	61	59	57	54	52	50	48	46	44
86	1.2527	.6153	96	92	88	85	82	78	75	72	69	67	64	61	59	57	55	52	50	48	46	45
87	1.2933	.6352	96	92	89	85	82	79	75	73	70	67	64	62	59	57	55	53	51	49	47	45
88	1.3346	.6555	96	92	89	85	82	79	76	73	70	67	65	62	60	58	55	53	51	49	47	45
89	1.3774	.6765	96	92	89	85	82	79	76	73	70	67	65	62	60	58	56	53	51	49	48	46
90	1.4211	0.6980	96	93	89	86	82	79	76	73	70	68	65	63	60	58	56	54	52	50	48	46
91	1.4661	.7201	96	93	89	86	82	79	76	74	71	68	66	63	61	59	56	54	52	50	48	47
92	1.5125	.7429	96	93	89	86	83	80	77	74	71	68	66	63	61	59	57	55	53	51	49	47
93	1.5600	.7662	96	93	89	86	83	80	77	74	71	69	66	64	61	59	57	55	53	51	49	47
94	1.6088	.7902	96	93	89	86	83	80	77	74	72	69	66	64	62	60	57	55	53	51	50	48
95	1.6591	0.8149	96	93	90	86	83	80	77	75	72	69	67	64	62	60	58	56	54	52	50	48
96	1.7108	.8403	96	93	90	86	83	80	77	75	72	69	67	65	62	60	58	56	54	52	50	49
97	1.7638	.8663	96	93	90	86	83	80	78	75	72	70	67	65	63	60	58	56	54	52	51	49
98	1.8181	.8930	96	93	90	87	83	81	78	75	72	70	67	65	63	61	58	57	55	53	51	49
99	1.8741	.9205	96	93	90	87	84	81	78	75	73	70	68	65	63	61	59	57	56	53	52	50
100	1.9316	0.9487	96	93	90	87	84	81	78	75	73	70	68	66	63	61	59	57	56	53	52	50
101	1.9904	.9776	97	93	90	87	84	81	78	76	73	71	68	66	64	61	59	58	56	54	52	50
102	2.0507	1.007	97	93	90	87	84	81	78	76	73	71	68	66	64	62	60	58	57	54	53	51
103	2.1128	1.038	97	93	90	87	84	81	79	76	73	71	69	66	64	62	60	58	57	54	53	51
104	2.1763	1.069	97	93	90	87	84	81	79	76	74	71	69	67	64	62	60	58	57	54	53	51
105	2.2414	1.101	97	93	90	87	84	82	79	76	74	71	69	67	65	63	60	59	58	55	53	51
106	2.3084	1.134	97	93	90	87	85	82	79	77	74	72	69	67	65	63	61	59	58	55	54	52
107	2.3770	1.168	97	94	90	87	85	82	79	77	74	72	70	67	65	63	61	59	58	55	54	53
108	2.4473	1.202	97	94	90	88	85	82	80	77	75	72	70	68	65	63	61	60	59	56	54	52
109	2.5196	1.238	97	94	91	88	85	82	80	77	75	72	70	68	66	64	61	60	59	56	55	53
110	2.5939	1.274	97	94	91	88	85	82	80	77	75	72	70	68	66	64	62	60	59	56	55	53
111	2.6692	1.311	97	94	91	88	85	83	80	78	75	73	70	68	66	64	62	60	59	57	55	53
112	2.7486	1.350	97	94	91	88	85	83	80	78	75	73	71	70	66	64	62	61	60	57	55	53
113	2.8280	1.389	97	94	91	88	86	83	81	78	76	73	71	70	67	65	62	61	60	57	56	54
114	2.9094	1.429	97	94	91	88	86	83	81	78	76	73	71	70	67	65	63	61	60	58	56	54
115	2.9929	1.470	97	94	91	88	86	83	81	78	76	73	71	70	67	65	63	61	61	58	56	54
116	3.0784	1.512	97	94	91	88	86	83	81	79	76	74	71	71	67	65	63	62	61	58	57	54
117	3.1660	1.555	97	94	91	88	86	84	81	79	76	74	72	71	68	65	63	62	61	59	57	55
118	3.2576	1.600	97	94	91	88	86	84	81	79	77	74	72	71	68	66	63	62	62	59	57	55
119	3.3492	1.645	97	94	91	88	86	84	82	79	77	74	72	71	68	66	64	63	62	59	57	55

†This table may be filed under P 207. if preferred. See sheet 1 for explanatory notes.

LAUGH with BARNEY

"Daddy, what is heredity?"

"Heredity, my boy, is what a man believes in until his son begins to act like a fool."

☆ ☆ ☆

A guest handed the hotel manager a bouquet of flowers. "It's for the 'phone girls," he said.

Pleased, the manager said: "Thank you, sir, thank you, sir. I know they will appreciate the compliment."

"Compliment," roared the guest. "I thought they all had died."

☆ ☆ ☆

Mrs. Newlyrich secured the services of a colored maid. After several days she noticed that the maid was taking home all the grapefruit skins. "Ruby," she said, "surely you don't eat those peelings?"

"No, ma'am," responded Ruby, "I takes 'em home because they sho do make my garbage look stylish."

☆ ☆ ☆

First soldier, regarding a group of girls with an exaggerated account of his part in capturing a small town: "Then an explosion tore up the main street."

Girls in unison: "Goodness! And what did you do?"

Second soldier, standing by: "He tore up a side street."

☆ ☆ ☆

A bathing suit is a garment that has been cut down to see level.—Philnews.

Joe saw the train but didn't stop,
So they dragged his car off to the shop.
And there, in just a week or two,
The car came out as good as new.
But though they've hunted high and low
There are no extra parts for Joe.

☆ ☆ ☆

A farmer, visiting his son at the university, took the boy downtown to have his photograph taken. The photographer suggested that the son stand with his hand on his father's shoulder. "It would be more appropriate," replied the father, "if he stood with his hand in my pocket!"

☆ ☆ ☆

"Just fancy," said the adoring mother, he's only seventeen months old and he's been walking for nearly nine months!"

"Really?" said the visitor wearily. "Don't you think it's about time he sat down?"

☆ ☆ ☆

The doctor rushed out of his study. "Get my kit at once!" he shouted.

"Why, Dad," asked the daughter, "what's the matter?"

"Some fellow just phoned he can't live five minutes without me," gasped the doctor, reaching for his hat.

His daughter breathed a sigh of relief. "Just a moment," she said quietly, "I think that call was for me."

"It's oil, LANE-WELLS on the job"

A man was reading a prepared address to a meeting of industrialists and he swung into his speech:

"The average businessman is tired. He has worked long and diligent in difficult times and he is weary. He is physically and mentally exhausted. But he isn't nearly as tired as the girls who have to type all this hogwash."

There came a long tense pause while a delighted audience began to yelp its appreciation. The speaker stared at his script in unbelief.

"Why," he blurted at last, "I never wrote anything like that!"

☆ ☆ ☆

Two inmates were conversing in their padded cell. I've just decided to buy all the diamond and emerald mines in the world," said one.

The second gent considered this for a few moments and then murmured softly, "Don't know as I care to sell."

☆ ☆ ☆

Vacations are easy to plan: the boss tells you when and the wife tells you where.—Anon.

☆ ☆ ☆

Political economy: Two words that should be divorced on the grounds of incompatability.—Air Conditioning & Refrigeration News.

☆ ☆ ☆

Russian speeches aren't copyrighted, but every one bears a tirade mark.—Wall Street Journal.

☆ ☆ ☆

Few things are so embarrassing as watching your boss do what you just said couldn't be done.

☆ ☆ ☆

In one of her exotic moments a famous dancer wrote to the late George Bernard Shaw and suggested that the two favor humanity with an incomparable offspring, saying:

"What a contribution to the human race we could make with a child who possessed your brain and my body."

To which Shaw replied:

"Have you ever thought of the catastrophe should that child happen to possess your brain and my body."

☆ ☆ ☆

A lady, somewhat embarrassed by the unexpected gift of an alligator, placed it in the bathtub temporarily before rushing out to keep an engagement. When she returned she found this note from her maid: "Sorry. Ise quit you-all. I doan want to work in a house where they's a alligator. I'd a-tole you but I didn't think the question would ever come up."

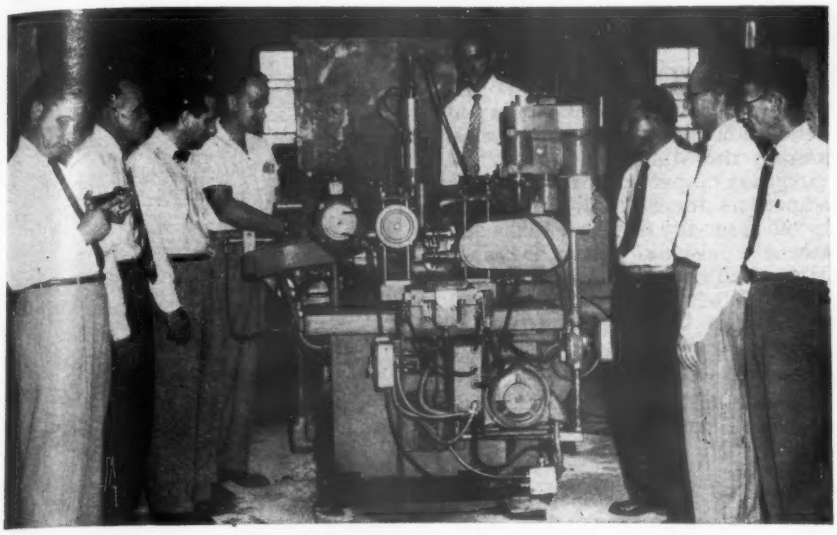
☆ ☆ ☆

A bargain is usually something you cannot use at a price you cannot resist.—Man's Shop.

☆ ☆ ☆

Happiness is that peculiar sensation you acquire when you are too busy to be miserable.—Mutual Moments.

OIL and GAS TRADE NEWS



EMPLOYEES from the Venezuelan offices of Socony-Vacuum inspect above machine for making valve stems while on a tour of the Houston plant of Mission Manufacturing Company recently. In the group are Villa Mizar, who is looking at a finished valve stem; Ignacio Romero; R. N. Ross of Magnolia, Houston; Arvo Ceepo of Mission, who designed the machine; Ted Fullinwider, Mission; Narcisco Rangel, Rafal Fraile, and George Kendall.

EMSCO to Market Ball Bearing Swivel Fittings

In a trend to wider diversification of the Emsco line of oil field and related products, the addition of a swivel fitting department has been announced by William T. Powell, president of Emsco Manufacturing Company. Emsco has acquired the swivel fitting business of the Rasmussen Manufacturing Company of Hollydale, California. Heading up the swivel fitting sales program will be E. R. (Pop) Atkins, long known in oil.

Bethlehem Opens Store At Whitesboro, Texas

Bethlehem Supply Company announces opening of its latest modern supply store at Whitesboro, Texas. The store is at 415 North Union in the city of Whitesboro, Texas, on State Highway No. 10.

The new store is under the supervision of W. E. Stephenson, district manager at Wichita Falls, Texas. C. W. Nichols, formerly field representative at the Odessa, Texas, store, is the new store manager.

Aerovent Opens New Building

Aerovent Fan Company, Inc., has announced the opening of its new general office building at 700 East Ash Street, Piqua, Ohio. The building proper includes 12 offices, a director's room, file room, drafting room, restrooms, ladies lounge, and a combination supply room and kitchen, each completely fireproof and soundproof. Coffee will be served from the kitchen daily at 10 and 2:30 to all guests.

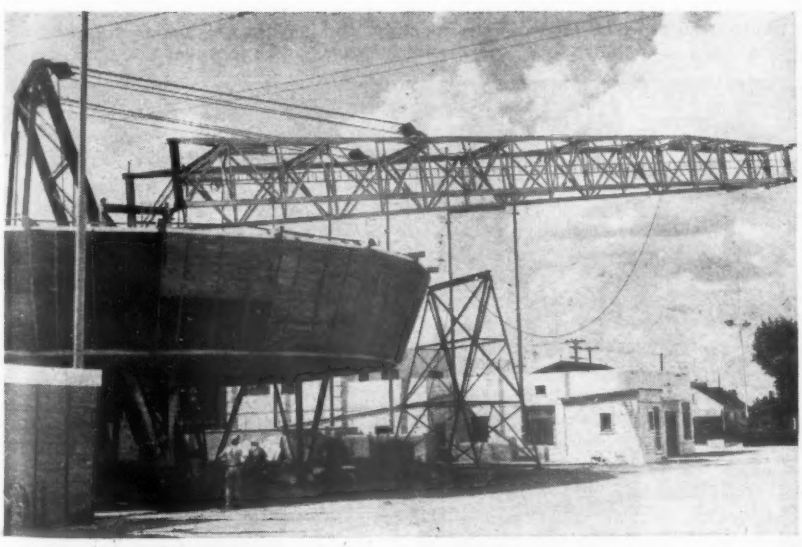
Branch Store Opened

The Continental Supply Company has opened a new branch store in Victoria, Texas, which houses both store and warehouse. G. K. Ashmead, formerly of the Alice, Texas, store is branch manager, and will be operated under the supervision of N. D. Lane.

IPE Display Moved

The answer to a question that baffled visitors to the International Petroleum Exposition last May—could the 140-ft drilling mast, in the center of National Supply Company's Rotorama, be removed without damaging the building has been reached.

The solution worked out by John Eaton, engineer for Lee C. Moore Corporation, was to erect an "A" frame, 45-ft high, inside the center of the doughnut-shaped building. Wire rope was fed through pulleys at the top of the "A" frame and fastened to the mast. The mast was hinged 25 ft above the ground. A second "A" frame was erected to one side of the Rotorama. Wire rope was played out slowly and top portion of the mast was lowered, until it rested on second "A" frame. Bottom portion was removed in sections.



NATIONAL SUPPLY'S IPE display being moved from the Oil Show grounds in Tulsa, Oklahoma. Right: **SITE** of drilling operations in the new Salta field in Argentina near the Bolivian border. Visitors to the operations are Ing. Juan B. Siri, president and general manager of YPF, Argentina oil concern, J. B. O'Connor, executive vice president, Dresser Industries, Inc., and Dr. Pedro S. Daneri, Undersecretary of Industry and Commerce. Picture was made during O'Connor's recent visit to Argentina.

Trade News

Du Pont Speaks on United States Defense

A potential enemy of the United States could weaken this nation far more effectively by striking subtly at American technology than he could by physical sabotage, Henry B. du Pont, a vice president of the Du Pont Company said in North Carolina recently.

He addressed the annual dinner of the Chamber of Commerce at Kinston.

Speaking on "Blueprint for Disaster," du Pont said the United States is more vulnerable to "economic sabotage" than it is to hostile action. An enemy's best tactics, he said, would be to prey upon the "misunderstandings and misapprehensions of our people and trick them into acting against their own country's best interest."

New Canadian Office Open

American Manufacturing Company of Texas has announced the opening of a new branch office in Canada at 616 Lancaster Building, Calgary, Alberta. M. A. (Hoot) Priester has been appointed sales representative for Canada and will be in charge of this office. Priester joined the American Manufacturing Company of Texas as a mechanic in 1942.

Guiberson Holds Meeting

The Guiberson Corporation held a general sales meeting at the plant in Dallas with more than 45 sales representatives and executives of the corporation attending recently. Keynoting the meeting, Gordon G. Guiberson, president announced, "We are pleased with our sales progress for the first part of the year. The upturn in drilling and production activity leads us to expect this increase to continue during the rest of 1953."

Sargent Establishes Mid-Continent Stores

Sargent Engineering Corporation has established its own sales and service field stores in fifteen Mid-Continent producing areas. George L. Sargent, director of oil well pump sales made the announcement.

M-H Opens New Dallas Office

A new 13,000-sq ft sales office and warehouse has been opened in Dallas, Texas, by the Minneapolis-Honeywell Regulator Company. It will also be headquarters for Honeywell's branch sales office serving northern Texas and northern Louisiana. Fred C. Brandt is Honeywell's regional manager.

Lane Wells Offices Opened

Lane-Wells Canadian Company has opened a new sales office in Regina, Saskatchewan, Canada. Ray E. Benjamin, well known geologist is in charge of the office, at 1913 South Railway Street.

Lane-Wells also has opened a new branch location at Newcastle, Wyoming. Lynn W. Day is in charge.

Sales Office Set Up

Harold D. Skyrm, vice president, General American Transportation Corporation, of Chicago, has announced opening of a Southern California sales office for the company's plate and welding division and the appointment of Ben King Duffy as district sales manager. The new office is in the Statler Center, 900 Wilshire Boulevard, Los Angeles. Skyrm also announced that a field erection shop is being constructed at Colton, California, to facilitate erection of Wiggins floating roofs and Wiggins conservation structures throughout the territory.

Bush Speaks to Dallas Civic Leaders

The Eisenhower administration is well on the road to a return to constitutional government, Senator Prescott S. Bush, of Connecticut, told some 180 Dallas business and civic leaders recently. Speaking at a luncheon in the Baker Hotel Terrace Room, the visiting senator cited the president's attitude on the tidelands issue as an example of his determination to decentralize federal government powers.

SENATOR BUSH, right, was presented a testimonial parchment in appreciation of his services as a former director of Dresser, by H. N. Mallon, president.

Bush directly or indirectly credited the present administration with three other "events" favorable to the nation's welfare. The tide of the cold war has turned in our favor, he believed. "We are fast recapturing control of the federal budget," he said.

GUIBERSON EMPLOYEES attending general sales meeting are: Front row, J. P. Killingsworth, C. B. Alexander, M. W. Breedlove, H. S. Zane, Jr., A. P. Smith, W. R. Guiberson, G. G. Guiberson, L. E. Vessels, R. Z. Mendenhall, Pat Sullivan. Second row, W. D. Watson, C. A. Teel, S. D. Beckley, E. C. Trott. E. E. Embury, O. A. Hess, C. L. Forcum, D. B. Carver, W. V. Phillips, D. L. Frv. P. L. Brown. R. L. Lindsay. Third row, R. J. Foreman, L. T. Ferguson, W. R. Forcum, C. E. Lance, F. H. Bronaugh, Frank Bridwell, P. P. Kizis, D. E. Ritchie, J. T. Anderson, H. M. Cherry. R. A. Day. Fourth row, B. M. Matthews, W. F. Meier, A. E. Brummett, R. L. McAdams, C. E. Winders, J. R. McManus, H. H. Louden, A. M. Alexander, L. E. Brookover, R. W. Lindsay, Jr., D. L. McGill. The meeting was held in the Dallas plant, where more than 45 sales representatives and executives attended.

TRADE PERSONALS

F. C. Hilker

H. G. Bentson

▸ **F. C. "Bud" Hilker,** public relations and advertising manager for the Eastman Oil Well Survey Company at Denver, Colorado, was elected national president of the Society of Associated Industrial Editors at the organization's convention held in Omaha, recently. Hilker, who has been with Eastman since 1948, is publications director for the company.

▸ **Hal G. Bentson** has been promoted to newly created position of chief sales engineer for Security Engineering Division, Whittier, California. Bentson was formerly assistant chief engineer for the company. In his new position, he will devote a major share of his time assisting oil companies and drilling contractors in solving production problems.

▸ **Robert L. McAlister** and **John T. Heffernan** have been appointed to the sales staff of the American Meter Company. McAlister was graduated from Eastern Illinois State Teachers College and Rose Polytechnic Institute. Prior to joining American Meter he was a chemist and assistant supervisor for Natural Gas Pipeline Company of America. Heffernan was graduated from Iowa State College, and the University of Washington.

▸ **Luther Evans,** formerly in charge of industrial relations for The Dow Chemical Company's Texas division, has been appointed to the newly created position of director of industrial relations for all Dow operations. His headquarters are in Midland.

▸ **C. L. Holbert** and **Rex D. Cross** have been appointed to new positions with Johnston Pump Company of Pasadena, California. Holbert, formerly vice president-treasurer, moves up to vice president-general manager. Cross will be national sales manager.

▸ **Fred W. Stakelbeck** has been named to the post of executive vice president of The Sharples Corporation. Stakelbeck joined the company in 1934.

▸ **Delpha L. Anderson,** assistant sales manager of Vickers Petroleum Company, Inc., has been named to the position of sales manager of the company. Anderson in 1948, joined the sales staff at Vickers and was promoted in 1951 to assistant sales manager.

▸ **Val R. Wittich, Jr.,** has been named exclusive export representative for Oil Metering and Processing Equipment Corporation, Vernon Smith, president of Oil Metering, has announced. Wittich, whose offices are at 30 Rockefeller Plaza, New York City, has been representing manufacturers of drilling, production, refining equipment since 1926.

Val R. Wittich, Jr.

▸ **H. W. Bierman** has been named sales engineer for Edward Valves, Inc., in Oklahoma and parts of Missouri, Kansas, Arkansas, and Texas. Bierman formerly at the Edward home office will make his headquarters at the Rockwell Manufacturing Company offices in Tulsa, Oklahoma.

▸ **M. R. Wingard** has been named sales engineer of the Chemical Plants Division of Blaw-Knox Company. Wingard will be at the Western Headquarters in Tulsa, Oklahoma.

▸ **Jerry Hutchison** has joined the tubular sales division of The Continental Supply Company. He will specialize in fibercast and plastic pipe sales. Hutchison will work out of Tulsa, Oklahoma.

▸ **L. C. Rhoads,** sales manager, Hercules Tool Company of Tulsa, has returned from an extended business trip throughout Colorado, Wyoming, Nebraska, and the Dakotas.

Messinger

Whitley

August

Jump

Viator

Harris

Leamon

▸ **Hal Messinger** has been named California district sales manager for Baash-Ross Tool Company. Messinger has operated for a number of years as Baash-Ross sales representative in the Los Angeles Basin area, Ventura and San Joaquin Valley.

Harold Whitely has been named to the sales operations of Baash-Ross' Odessa-Midland organization. Whitely is familiar with field operations in this area, having worked in the West Texas fields with several drilling contractors for a number of years, as well as in sales and service for oil tool supply organizations. He will make his headquarters in the Odessa offices.

▸ **C. J. Jump** has recently been named by Republic Supply as district manager of the Rocky Mountain area and will locate his office in Denver, Colorado. Jump will reside in Denver, and in addition to his duties as district manager of the new area, he will be in charge of city sales.

Alex L. August has been appointed district manager of the Shreveport district of Republic Supply Company. He succeeds **W. M. Haynes** who has resigned. August joined Republic Supply at Corpus Christi, Texas, in 1949.

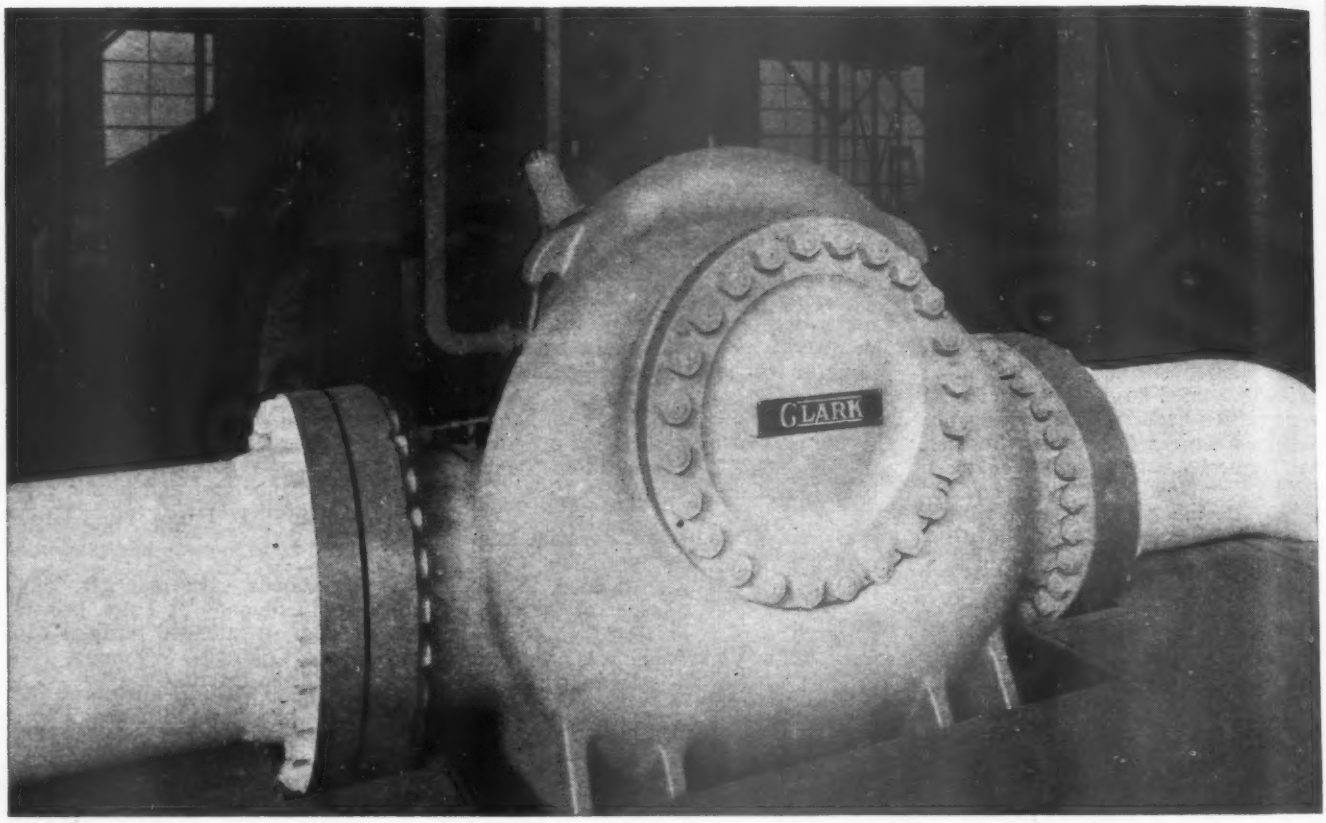
▸ **Joe Viator** has been appointed WECO sales representative in Southern Arkansas, East Texas, and Southern Louisiana, for Well Equipment Manufacturing Corporation. He will make his headquarters in Shreveport, Louisiana. Viator was formerly with Bethlehem Supply Company.

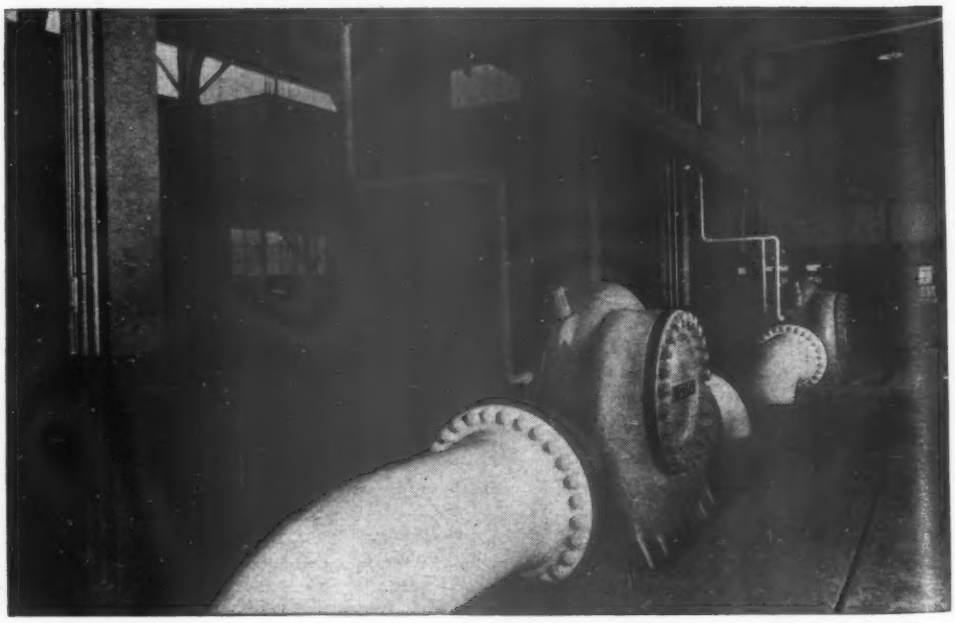
▸ **Jack W. Harris** has been named sales engineer by Beaumont Iron Works Company in charge of valve sales for process industries, and general industrial applications. Valves will be marketed by Beaumont and Alco offices.

Harris' extensive background in the design and sales of specialized valves with Cameron Iron Works, Inc., as well as his experience with Gulf Refining, J. S. Abercrombie Company and Harrison Oil equip him for this work. He is a graduate of Rice Institute. His office will be in the general sales office of Beaumont Iron Works in Houston, Texas.

▸ **Ben F. Leaman, Jr.,** has been appointed sales manager of the new sound control products sales division of Owens-Corning Fiberglas Corporation.

EFFICIENCY





Two Clark 5000 BHP Centrifugal Pipeline Compressors installed at the Cornudas, Texas station of El Paso Natural Gas Company. Note the accessibility and simplified piping made possible by the straight-thru design. Six other Clark Centrifugals and 107 Clark "Right Angles" and "Big Angles" are used at other El Paso compressor stations.

TO SPARE!

Guaranteed efficiencies exceeded by the 8 Clark Centrifugal Pipeline Compressors in El Paso Natural Gas Company's main line stations

It's a fact: The eight Clark Single Seal Centrifugal Pipeline Compressors being operated by El Paso Natural Gas Company at Cornudas, Texas and three other stations are among the most efficient compressors ever built!

Again, the intensive Clark research and development program has paid off. Not only have the latest hydraulic and mechanical engineering principles been incorporated in the casing design, but these principles were first thoroughly proved in the shop under full-load field conditions by use of a closed loop test.

Of equal importance is the development of the Clark Balanced Flo Impeller which provides the greatest possible thru-put of gas with minimum power consumption.

Designed and tested to operate at higher than current working pressures, these Clark Centrifugal Pipeline Compressors can easily and efficiently handle future requirements with relatively simple internal modification. The extra rugged casing is built to take it!

Clark Centrifugal Pipeline Compressors — electric motor, gas and steam turbine driven — are today operating on many of the nation's largest pipelines.

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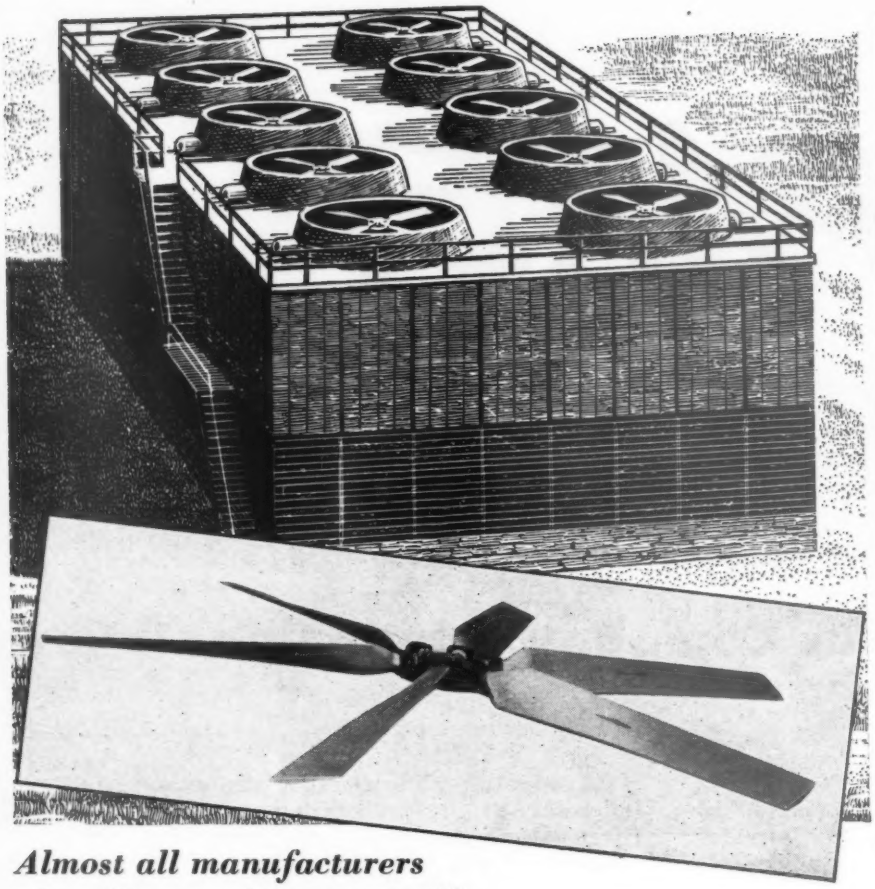

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Name.....

Title.....Company.....

City.....Zone.....State.....

Trade Personals

▸ **Frank Kelso** and **John Tatum** have been appointed Oklahoma and West Texas service engineers for the Martin-Decker Corporation and will be in Ok-

F. Kelso

J. Tatum

lahoma City and Odessa respectively. Kelso, a UCLA graduate, is being transferred to the Oklahoma area after a year's service with Martin-Decker Corporation at Odessa. In his new duties he will be working with **E. M. "Mutt" Donovan,** Mid-Continent sales engineer with headquarters at Oklahoma City.

▸ **George F. Klein, Jr.,** has assumed his duties as chief engineer for Mechanical Design, Inc., affiliate of Refinery Engineering Company. Klein, a graduate of the University of Missouri, received his Bachelor of Science degree in chemical engineering in 1938.

▸ **Douglas Edward Daffin,** service operations manager of Otis Pressure Control, Dallas, is in the rich Middle East oil fields helping American oil companies with production problems. Daffin is assisting Arabian-American Oil Company of Saudi Arabia in the servicing of Otis equipment in the Abquiq field. He will then go to Kuwait to aid the Kuwait Oil Company (Ltd.) along similar lines.

▸ **E. W. "Al" Forrow** has been named Kobe's manager of perforated sales according to L. T. Wold, vice president and general manager of Kobe Inc. division of Dresser Equipment.

In his new position with Kobe, Forrow will have headquarters at the company's perforating plant, Long Beach, California.

▸ **Jack C. Bever** has been named district representative for The Frank G. Hough Company. He will operate in the sales district comprising the District of Columbia, Maryland, Virginia, West Virginia, and the Carolinas. **Dwain Richey,** another district representative, will travel in Arkansas, Louisiana, Oklahoma, Texas, and New Mexico.

▸ **O. L. "Tony" Seachris** was recently named sales manager of Acme Tool Company. Seachris has many years of oil field experience behind him, having spent 15 years as a driller and tool pusher, plus another 6 years as a fishing tool operator in Oklahoma, Kansas and North Texas. Outside of his years as an independent operator, most of his experience has been with Acme.

Trade Personals

Dana C. Lovejoy, Jr., advertising man and sales analyst, has joined the staff of Darwin H. Clark Company, Los Angeles industrial advertising agency. Lovejoy was affiliated with Baroid Sales Division of National Lead Company in both Los Angeles and Houston—for five years as assistant advertising manager and for one year as head of the sales statistical analysis research department which he organized.

Norman E. Hathaway, sales manager of the industrial chemicals department of The Davison Chemical Corporation, has been granted a six months' leave of absence by the company to serve as director of the chemicals and rubber division of the chemical, rubber, and forest products bureau in the successor agency to the National Production Authority. In his absence from Davison, his duties there will be assumed by **David P. Barrett,** assistant sales manager of the industrial chemicals department.

Roy C. Stringfellow is new district manager of the Shreveport, Louisiana, district for Magnet Cove Barium Corporation. He was formerly a field service engineer for Magcobar in this area. He attended Centenary College.

New manager of Regina, Saskatchewan, district is **Harold A. Fogarty,** who was a former field service engineer. He attended the University of Oklahoma. **James E. Carlton** will manage the Laurel, Mississippi, district. He is a graduate of Texas A. & M. **Thomas L. Cox** has been named to manage the northern Oklahoma district with headquarters at Enid. He is a graduate of Oklahoma City University. The southern Oklahoma district will be managed by **Cleron L. Henderson.** His headquarters will be in Ardmore. He is a graduate of Oklahoma A. & M.

Howard C. Shireman has been named assistant sales manager for Merla Tool Corporation. This appointment is a newly created position of Merla Tool with headquarters in Dallas, Texas. Shireman has been associated for the past 19 years with National Supply Company, Welex Jet, and Dia-Log.

J. F. Catalane has been named sales manager of the P&H small excavator division, Harnischfeger Corporation. Catalane succeeds **F. C. Edwards,** recently appointed general manager of the P&H diesel division, at Crystal Lake, Illinois.

Robert P. Jones will assume the duties of assistant sales manager of the small excavator division. Jones has previously been with P&H in a sales development capacity.

William L. Whitcomb has been appointed assistant to the director of advertising of Glass Fibers, Inc. In his new capacity, Whitcomb will supervise the merchandising material, inquiry, photographic, and advertising budget sections.

R. E. Bansemer, assistant sales manager at Koehring Company has been named sales manager for Parsons and **M. O. Messenger,** sales manager at Parsons Company's Iowa plant, has moved to Milwaukee to take over the assistant sales manager's duties in the parent company.

Thomas R. McIntyre of Calgary, Alberta, will represent Hercules Tool Company in the Provinces of Alberta and Saskatchewan, Canada. **W. W. Coonrod** of Great Bend has been appointed field representative in the state of Kansas, and **A. D. Eastham** in the Texas Panhandle area.

John T. Young has been named sales representative for the Western Division of Canadian Meter Company, Ltd., Canadian division of American Meter Company. As a member of the Western Division of Canadian Meter Company, Young will be closely associated with Frank Barchard.

V. J. (Mike) Mercier and **R. N. (Dick) Brammer** have joined the staff of The Western Company, technical oil well servicing company with general offices in Midland, Texas. Mercier has been assigned to the Odessa area.

Mike Smith, with Cardinal Chemical, Inc., as treating engineer at Levelland, Texas, since 1952, is transferred to the Cardinal station at Hobbs, New Mexico, as manager. **Eddie Freund,** treating engineer is also transferred to Hobbs, from Odessa, where he has been treating engineer since June. **M. W. "Pat" Sharp** was added to the Hobbs staff as treating engineer.

Jim Ormond, Odessa station manager since 1952, is promoted to development engineer. Ormond originally joined Cardinal in 1952. **G. W. Radney,** with Cardinal since 1949, replaces Ormond.

J. T. "Sonny" Mobley, truck driver at the Odessa station since June is promoted to treating engineer.

Joe Overton has been added to the staff as treating engineer.

William Kerin, Jr., Franklin Supply Company, formerly district sales manager at Mt. Pleasant, Michigan, has been transferred to Oklahoma City in the same capacity. **Charles Armstrong,** salesman at Casper, Wyoming, has been transferred to Mount Pleasant as district sales manager. **Frank A. Northway** has been transferred from Tulsa, Oklahoma, to Dallas, Texas.

Lee Croger, formerly store manager at Grayville, Illinois, assumes managership of the East Chicago, Indiana, store. **Wendell Kalck** has been promoted from the tubular department of the general office to sales at Grayville, Illinois.

Frank Dorney, recently released by PAD in Washington, assumes the job of salesman at Tulsa. **Don Davis** has been transferred from his sales duties in Grayville, to Casper, Wyoming. **Jack Connell** has been promoted from the purchasing department to store manager at Casper, Wyoming.

HOW TO ELIMINATE JOINT PREPARATION AND CUT COSTS

USING high current densities of Manual Lincolnweld, 100% butt welds in ¾" square edged plates are now made with single pass welds from each side. Costly manhours and expense for bevelling plates can be eliminated to speed fabrication and lower shop costs.

Exceptionally deep penetration attained with Manual Lincolnweld's "hidden-arc" welding comes from concentrating up to 600 amps on a small diameter (5/64") electrode. Compared with hand welding with coated electrodes, this current concentration approximates 10,000 amps on a ¼" rod.

And here are other important cost-saving benefits. With Lincoln's "hidden-arc" welding, welds are of X-ray quality, are made 2 to 4 times faster, require little if any cleaning. And welding is simpler. The electrode is fed automatically maintaining a pre-set arc length throughout the weld. Versatile for a wide range of work, Manual Lincolnweld's gun can be hand operated (Fig. 1) or held in extremely simple fixtures (Fig. 2) to provide all the benefits of "hidden-arc" welding, yet retaining the advantages of manual operation.

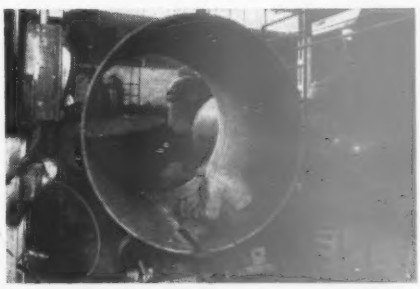

Fig. 1. Hand Operation—*Completes inside weld in one pass to fabricate pressure vessel using Manual Lincolnweld's high-density "hidden-arc" welding. Welding speed is 17" per minute.*

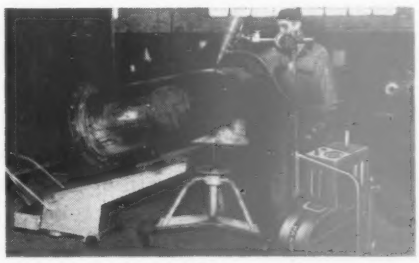

Fig. 2. Fixture Mounted—*Manual Lincolnweld saves 30% in direct labor alone in fabrication of pipe fittings. Photo courtesy Flori Pipe Company, St. Louis, Mo.*

Send for latest welding procedures

Welding Speeds and Procedures with Manual Lincolnweld are available in Bulletin 1303, available by writing on your letterhead to Dept. 2811,

THE LINCOLN ELECTRIC COMPANY
Cleveland 17, Ohio
THE WORLD'S LARGEST MANUFACTURER OF ARC WELDING EQUIPMENT

Get a SERVICE CHECK NOW

TO BE SURE YOUR EMULSION-BREAKING IS RIGHT FOR WINTER

THIS Visco ad is looking for NEW BUSINESS... Visco users *are* ready for efficient emulsion-breaking this winter. And *you* too, can be secure for all weather by asking for a Visco Service Check *NOW*. No obligation to you...Yet an excellent chance for permanent freedom from emulsion-breaking worries. Write today—or phone Houston, CAPITOL 7300, collect, for fast action!

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Visco... CONSISTENTLY EFFICIENT
DEHYDRATING AND DESALTING CHEMICALS

New Machinery and Supplies

Use reply card to procure promptly complete information and prices of products described here in brief.

Circle corresponding letter or letters on reply card

(A) COUPLING FOR PIPE

The "Gruvajoint" is a new lightweight coupling for grooved pipe systems designed and produced by Gustin-Bacon Manufacturing Company. Gruvajoints are specifically designed to save time, weight, freight, and space in coupling grooved pipe systems where pressures do not exceed 500 psi.

Circle letter (A) on reply card.

(B) PRESSURE CELLS

New high frequency pressure cells of SR-4 Type HF are announced by Baldwin-Lima-Hamilton Corporation. Cells are of five standard capacities: 1000, 2000, 5000, 10,000, and 20,000 psi, and other capacities are available. Cells consist of a pressure sensitive tube on the outside of which special SR-4 strain gages are bonded.

Circle letter (B) on reply card.

(C) VACUUM PUMP

High pumping speed in the pressure range from 6×10^{-3} to $5 \times {}^{-2}$ millimeters of mercury is one of the outstanding features of a new vacuum pump now being produced by Consolidated Vacuum Corporation (formerly the Vacuum Equipment Department of Distillation Products Industries.) The new unit, designated as the single-stage oil ejector pump, type KB-1500, is specifically designed for use in large volume dehydration and vacuum metallurgical systems.

Circle letter (C) on reply card.

(D) DIESEL ENGINES

In operations up and down the Gulf Coast Kerr-McGee's Rig No. 40 has drilled almost 200,000 ft of hole with power provided General Motors diesel engines from Stewart and Stevenson Services. The rig is presently powered by three GM quads on an Emsco 1660 drawworks that were part of the original equipment when it was built back in 1949. Two more GM's — model 6-110s — were added this year, each driving 100 kw a-c generator sets at 1200 rpm. Fifty per cent of these engines have not had a major overhaul since originally put in service.

Circle letter (D) on reply card.

(E) TRIPLEX PUMP

An ideal Type F-90 triplex pump is being utilized as a salt water disposal unit by the Superior Oil Company in the Gosford area near Bakersfield, California. The 3-cylinder single-acting pump is rated at 90 hydraulic horsepower output at maximum speed of 360 rpm. Using 1¾-in. ceramic plungers, it is capable of pumping 1920 bbl per day at 2745 psi discharge pressure. It is one of the newest additions to The National Supply Company family of pumps.

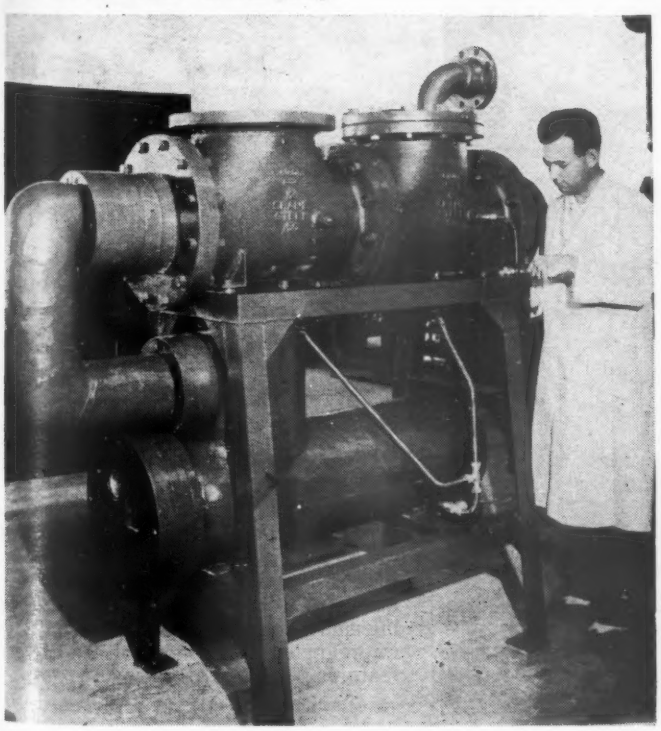
Circle letter (E) on reply card.

(F) INJECTOR CONTROL

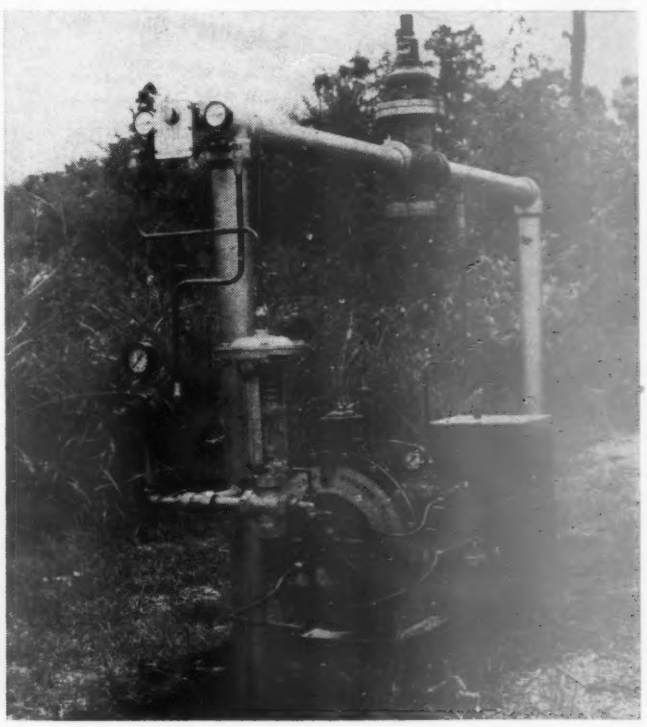
The Textroller control hook-up was devised primarily to control the injection of alcohol, methanol, and similar anti-freeze solutions into the stream when the temperature of the stream dictated the need for the solution, Texsteam Corporation reports. The operation is very simple and installation is easy to make. The Textroller is a temperature operated pilot.

Circle letter (F) on reply card.

CONSOLIDATED vacuum pump.



TEXSTEAM Corporation injector control.



New Equipment

(G) DIESEL GENERATOR

A new 1000 kw portable diesel generator set is added to the Enterprise Engine and Machinery Company line. Recently shipped to the Far East the unit shown is one of several new generating electrical power at remote points. The heavy duty diesel generator unit is self-contained on a skid mount.

Circle letter (G) on reply card.

(H) VALVE PULLER

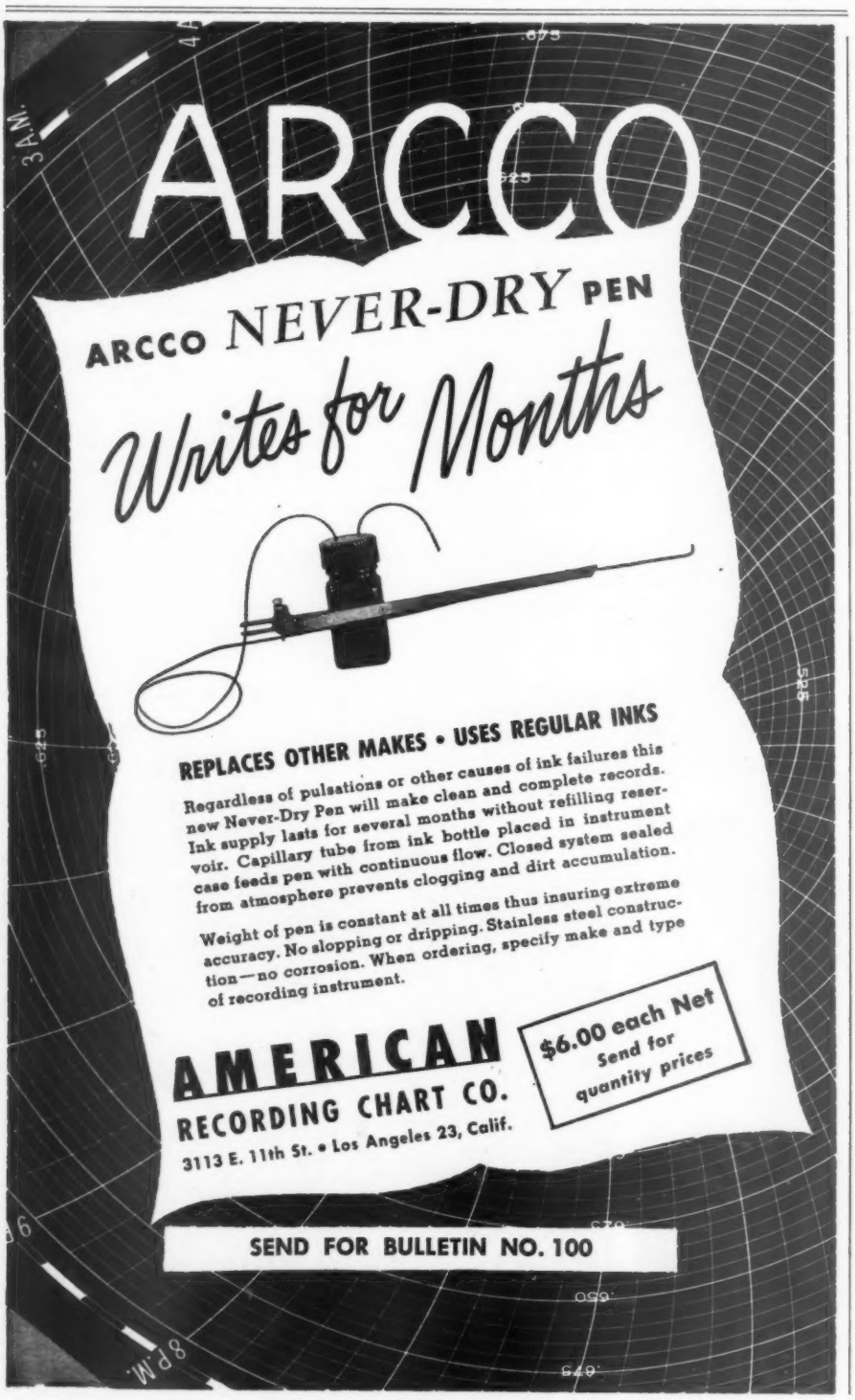
A positive-acting, highly simplified tap-type standing valve puller is announced by D+B Division, Emsco Manufacturing Company. It consists of only five parts: Body, housing, spring, key pin, and tap. Any of these parts may be changed in the field. As a result, the unit does not have to be discarded when only one or two parts are worn.

Circle letter (H) on reply card.

(I) WELDING POSITIONERS

As an addition to its complete line of welding positioners and turning rolls, Worthington Corporation has announced three new heavy-duty precision positioners for automatic or manual welding. The new units are being built in 2500, 3000, and 6000 lb capacities. For these precision machines, Worthington has designed and developed a special variable speed drive.

Circle letter (I) on reply card.


ARCCO
ARCCO NEVER-DRY PEN
Writes for Months
REPLACES OTHER MAKES • USES REGULAR INKS
Regardless of pulsations or other causes of ink failures this new Never-Dry Pen will make clean and complete records. Ink supply lasts for several months without refilling reservoir. Capillary tube from ink bottle placed in instrument case feeds pen with continuous flow. Closed system sealed from atmosphere prevents clogging and dirt accumulation.
Weight of pen is constant at all times thus insuring extreme accuracy. No slopping or dripping. Stainless steel construction—no corrosion. When ordering, specify make and type of recording instrument.
AMERICAN
RECORDING CHART CO.
3113 E. 11th St. • Los Angeles 23, Calif.
$6.00 each Net
Send for quantity prices
SEND FOR BULLETIN NO. 100

(J) PLASTIC PIPE

Latest developments have been announced in a new type of plastic pipe pioneered and manufactured by the Reflin Company. Reflin pipe is said to have overcome many of the limitations of presently used plastic pipe materials which previously have limited the widespread acceptance of plastic pipe. It is available in larger diameter (ranging from 4 in. to 10 in.).

Circle letter (J) on reply card.

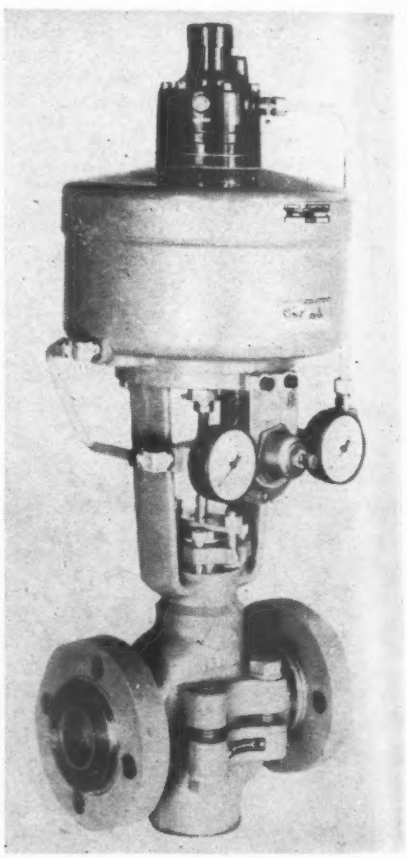
(K) ELECTRIC PLANTS

Two new gasoline-driven electric plants, rated at about 10,000 and 15,000 watts a-c have been added to the water-cooled line of engine-generators manufactured by D. W. Onan and Sons, Inc. These new "HQ" models are powered by Continental 4-cylinder, water-cooled engines and were designed to provide electric power for both primary and standby applications.

Circle letter (K) on reply card.

(L) CONTROL VALVE LINE

Conoflow Corporation recently announced a completely new line of control valves to be known as their LB series. Coupled with a completely new single seated, split body valve design,



the combination results in an assembly that promises to fulfill requirements of the process industries. Topwork consists essentially of an aluminum cylinder with carefully bored and honed internals, a plastic piston with graphite impregnated "O" ring seal, and other features.

Circle letter (L) on reply card.

(M) PLUG VALVES

A new line of semi-steel and steel lubricated plug valves is now offered to industry by The William Powell Company. Features of the new Powell lubricated plug valves include quick and positive shut-off. All are wrench-operated and require only a quarter turn to open or close the valve. Lubricant grooves surrounding each port provide a positive seal when these precision built and accurately fitted valves are closed. In an open position, seating surfaces are not exposed.

Circle letter (M) on reply card.

(N) BARREL SHAPED ROLLERS

Hyatt Bearings Division of General Motors Corporation has announced that, for the first time, its exclusive self-aligning "Barrel Bearing" is available in volume quantities for general industrial applications. John R. Gilmartin, general sales manager of the organization said that the recently expanded Hyatt bearings plant at Clark Township, New Jersey, will provide the additional facilities for expanded production.

Circle letter (N) on reply card.

(O) ADSORPTION CAPACITY

Introduction of PA-400, a high efficiency refrigerant desiccant, is announced by The Davison Chemical Corporation. Developed after extensive research as part of Davison's program for "custom building" for silica gel desiccants for specific uses, it has nearly double the moisture adsorption capacity of PA-100, the product which Davison has previously offered for most refrigerant applications, and which PA-400 is expected to supplant. If moisture is present in the commonly used refrigerants freeze-ups are likely to be caused in the system.

Circle letter (O) on reply card.

(P) GAS METER

A new lightweight die-cast aluminum gas meter with a rated capacity of 415 cu ft per hour has been announced by Rockwell Manufacturing Company. Similar in body and cover design to two other aluminum meters previously introduced by the company — meters with capacities of 150 and 800 cu ft, respectively — the new "415" weighs only 20 lb as compared with Rockwell's cast iron meters of comparable capacity, which weigh 62 lb. Like the "150" and the "800," the new meter has a single sealing flange between cover and body.

Circle letter (P) on reply card.

Statement Required by the Act of August 24, 1912, as Amended by the Acts of March 3, 1933, and July 2, 1946 (Title 39, United States Code, Section 233) Showing the Ownership, Management, and Circulation of

THE PETROLEUM ENGINEER

Published Monthly, Semi-Monthly in July, at Dallas, Texas, for October 1, 1953.

1. The names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher: The Petroleum Engineer Publishing Company, P. O. Box 1589, Dallas, Texas.

Executive Editor: K. C. Sclater, P. O. Box 1589, Dallas, Texas.

Editor-in-Chief: F. H. Love, P. O. Box 1589, Dallas, Texas.

Managing Editor: Ernestine Adams, P. O. Box 1589, Dallas, Texas.

Business Manager: W. T. Bryan, P. O. Box 1589, Dallas, Texas.

Advertising Manager: T. J. Crowley, P. O. Box 1589, Dallas, Texas.

2. The owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding 1 percent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a partnership or other unincorporated firm, its name and address, as well as that of each individual member, must be given.)

W. T. Bryan, P. O. Box 1589, Dallas, Texas.
T. J. Crowley, P. O. Box 1589, Dallas Texas.
Pearle Nesbitt Love, P. O. Box 1589, Dallas, Texas.
K. C. Sclater, P. O. Box 1589, Dallas, Texas.

3. The known bondholders, mortgagees, and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)

NONE

4. Paragraphs 2 and 3 include, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting; also the statements in the two paragraphs show the affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner.

W. T. Bryan, Business Manager.

Sworn to and subscribed before me this 29th day of September, 1953.

[Seal] Lillian H. Johnston
Notary Public, Dallas County.
(My commission expires June 1, 1955.)

The S. D. DAY Company

Serving the Oil and Gas Industry

Pictured here are some typical applications of coating and wrapping products distributed by S. D. Day Company.

National Distributor
THE RUBEROID COMPANY*
Pipe Line Asbestos Felt

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Hot Applied Coal Tar Enamels for Pipe Lines

Cold Applied Coal Tar Coatings for General Industry

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Write, wire or telephone for literature, prices and engineering counsel.

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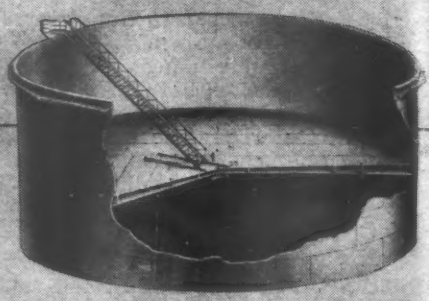
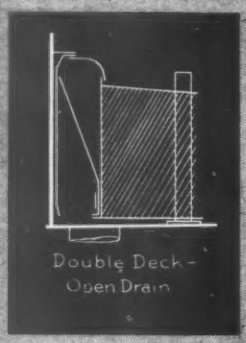
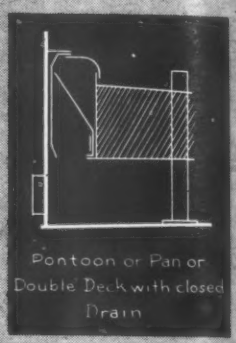
operators of floating roof tanks

You can get...

substantially more capacity from floating roof tanks.







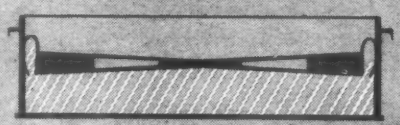
because: they can be made to travel right down to the floor of the tank, thus permitting *all of the tank capacity to be used.*

There are no fittings or supports to take up valuable storage space in Hammond designed and built Floating Roof Tanks . . . their Springtite Seal Floating Roofs can travel from the top of the tank right down to the floor so that all of the tank capacity can be used . . . this design and construction in no way sacrifices any of the values required of a floating roof tank.

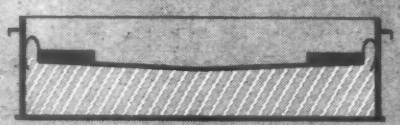
Hammond Floating Roofs reduce evaporation and breathing losses, eliminate filling losses, minimize fire hazards and decrease corrosion

. . . and they permit all of the tank capacity to be used.

HAMMOND FEATURES THREE TYPES OF FLOATING ROOFS



DOUBLE-DECK SPRINGTITE FLOATING ROOF



LOW SPRINGTITE FLOATING ROOF

HIGH SPRINGTITE FLOATING ROOF

. . . for full details write for Bulletin 51 F.

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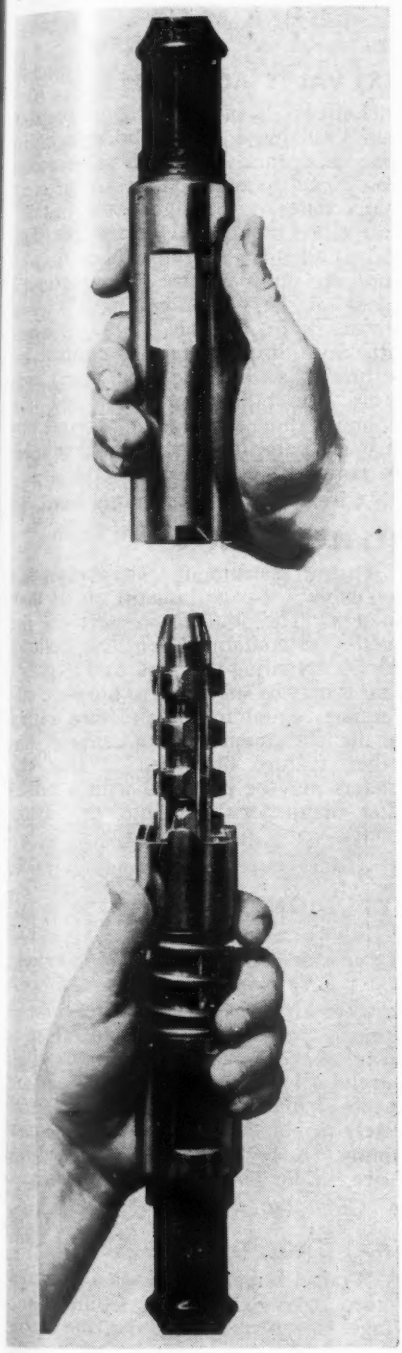
Sales Offices: NEW YORK 20 • AKRON • BOSTON 10 • BUFFALO 2 • CHICAGO 3 • CINCINNATI 2 • CLEVELAND 15 • EL PASO • HOUSTON 2 • LOS ANGELES 14 • PITTSBURGH 19 RICHMOND 20 • SAN FRANCISCO • WASHINGTON 6, D. C. • HAVANA • "TIPSA," BUENOS AIRES

ON THE PACIFIC COAST BY **LACY** MFG. CO. • LOS ANGELES, CAL. • IN CANADA BY **VULCAN** IRON & ENG. LTD. • WINNIPEG

New Equipment

(Q) SUCKER ROD ATTACHMENT

Page Oil Tools, Inc., announce the availability of a new Page sucker rod attachment. This new tool assures quick and easy connection or disconnection of sucker rods at the pump. To operate, run the pump in on the tubing with the lower end of the Page tool in place. Then lower the rods with the matching ends of the tool attached.



Circle letter (Q) on reply card.

(R) REFLECTOR LAMPS

An expanded line of reflector lamps is now available from Westinghouse Electric Corporation. Reflector lamps require no labor for maintenance other than relamping. The new line includes six lamps of various ratings and beam spreads.

Circle letter (R) on reply card.

Durametallic
Engineered Sealing

The PERFECT SEAL

an important cog
in America's defense
and domestic production program

Durametallic is geared to engineer or produce
the very best in metallic packings and mechanical
seals for refineries, chemical plants, pipe lines, ships,
power, synthetic rubber and general industry. . .

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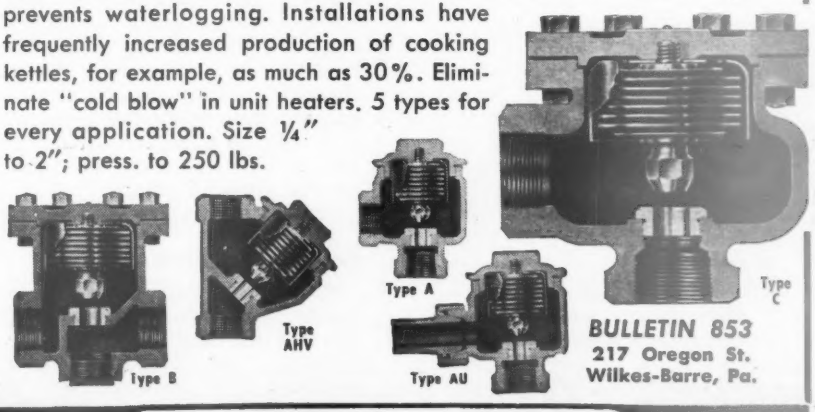
DURAMETALLIC CORPORATION
KALAMAZOO MICHIGAN

Nicholson Steam Traps Require

NO CHANGE of VALVE or SEAT, 0 to 250 Lbs.

Nicholson steam traps save the time and trouble of adjusting valves for varying pressures. This feature substantially speeds production and maintenance. Made of hardened stainless steel, the valve is extra large, resulting in from 2 to 6 times average drainage capacity. Both valve and seat are renewable. The fast action of Nicholson traps prevents waterlogging. Installations have frequently increased production of cooking kettles, for example, as much as 30%. Eliminate "cold blow" in unit heaters. 5 types for every application. Size ¼" to 2"; press. to 250 lbs.



BULLETIN 853
217 Oregon St.
Wilkes-Barre, Pa.

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ACME

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• Competent Operators
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• Spang Cable Tools • Drill Pipe
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• Complete Oil Field Machine Shop

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Trade Literature

Publication will be sent free.

(S) PRICE LIST

Lane-Wells Company recently announced publication of a catalog containing revised general terms and conditions attending all its services and packer price list. It is a list of prices written in chart form, making a handy reference list. James D. Hughes, general sales manager, explained that increasing labor and material costs made increases necessary.

Circle letter (S) on reply card.

(T) TESTING INSTRUMENTS

A buyer's guide on electric testing instruments has been announced as available from the General Electric Company. The new 16-page bulletin, designated GEA-5469B, provides data on such instruments as hook-on volt-ammeters, hook-on wattmeters, hook-on power-factor meters, portable recorders, voltmeters and ammeters, etc.

Circle letter (T) on reply card.

(U) SHOVELS-CRANES

The Thew Shovel Company has just published a new book on the construction of its Lorain-TL Series of shovels-cranes, entitled "The Inside Story on the Package Component Design of the Thew Lorain TL Series." It is a "Trans-Vision" presentation that enables one to see "inside" the machine. One of the features of the Lorain TL Series of power shovels and cranes is the "packaged assembly" of the turntable.

Circle letter (U) on reply card.

(V) HIGH VACUUM APPLICATIONS

Completely revised and containing a great deal of additional information, charts and data, is a new 60-page bulletin on high vacuum applications now available from Central Scientific Company. Included are many pages of factual data on such subjects as planning the high vacuum system; connections and speed of evacuations; selection of high vacuum pumping systems, etc., as well as illustrations and descriptions of various types of pumps.

Circle letter (V) on reply card.

(W) JET CASING CUTTERS

A new four-page, illustrated technical bulletin, No. 601, on jet casing cutters has just been released by the McCullough Tool Company. This technical folder gives a complete description of the applications and operation of McCullough jet casing cutters. It gives full details on the use of these wire line tools in casing recovery operations.

Circle letter (W) on reply card.

(X) VALVE ACTUATORS

Ledeen Manufacturing Company has available a 4-page bulletin on its pneumatic and hydraulic valve actuators. These valve actuators, the company states, are designed for installation either on new valves or on existing valves already in service. They may be mounted at the valve manufacturer's plant, at the valve distributor's warehouse, or on the job. They are available with direct or remote control, instrument, action, and emergency controls. The bulletin is illustrated and contains three tables giving torque ratings and capacity of actuating cylinders in pounds.

Circle letter (X) on reply card.

(Y) FLOW METERS

Barton Instrument Corporation has available a 7-page bulletin on its flow meters. The bulletin describes the meters as containing sensitive bellows for its actuating element, and explains that it may be subjected to pressure differences equal to the pressure rating of the instrument without damage. Another feature described is that the meters may be provided with a pulsation dempener built into the mete body.

Circle letter (Y) on reply card.

(Z) UNIONS

The Guiberson Corporation has issued a leaflet describing Seal-O-Matic unions, heavy duty couplings that are reported to stand up to the severest tests. Double-sealing Seal-O-Matic ring and metal to metal seat hold working pressures securely. All metal parts of the unions are made of high tensile alloy steel, accurately machined to assure interchangeability. On the back of the leaflet is a price list for the Seal-O-Matic Union.

Circle letter (Z) on reply card.

(AA) GAGE GLASSES

A 4-page bulletin may now be obtained from Ernst Water Column and Gage Company describing the company's gage glasses—tubular, round, and caliperated. The bulletin is profusely illustrated with the Ernst specialties, depicting the various products put out by the company.

Circle letter (AA) on reply card.

(AB) AIR CONDITIONING FILTERS

A new 8-page illustrated bulletin describing Staynew ventilation and air conditioning filters has been announced by the Dollinger Corporation. The bulletin contains specifications, engineering and performance data covering dry type panel filters recommended for the removal of air-borne impurities.

Circle letter (AB) on reply card.

(AC) MECHANICAL SEALS

A 20-minute, full-color film on mechanical shaft seals for centrifugal pumps is now available through Byron Jackson Company. Designed for showings to engineering and maintenance meetings, this film covers mechanical seals from design to maintenance. Various seal types and their applications are described.

Also available is a condensed transcript of this film in bulletin form, complete with photographs and drawings.

Circle letter (AC) on reply card.

(AD) PROCESS EQUIPMENT

Now available is an 8-page bulletin on Whitlock process equipment, published by the Whitlock Manufacturing Company. The catalog describes and illustrates Whitlock standard heat exchangers of several different designs as commonly built for the process industries. Details of design and construction are presented in this booklet, along with numerous tables giving specifications and types.

Circle letter (AD) on reply card.

(AE) COMBUSTION PROCESSES

"Oxygen-Index of Combustion Processes" is a new bulletin which graphically illustrates and explains how too much or too little air can have costly effects in combustion processes. It points out that by using oxygen itself as the criterion to proper combustion, greater overall process efficiency and more profits can be realized. The bulletin shows how oxygen in flue gases will indicate almost exactly the same excess air factor for any fuel.

Circle letter (AE) on reply card.

(AF) MANUAL CONTROL

Barksdale Valve Company has published an 8-page article on manual control valves for fuel, hydraulic oil, gas, petroleum, etc. The "Shear-Seal" principle employed in Barksdale valves is said to consist primarily of a pressure-balanced, self-aligned tubular valve seat, which is constantly in perfect contact with optically flat rotor by means of heavy marcel compression spring, (for low pressures and vacuums), plus a predetermined hydraulic force (for extreme pressures).

Circle letter (AF) on reply card.

(AG) GATE VALVES

An informative and completely illustrated four-page circular, describing its complete line of all-iron and iron body, bronze mounted "King-clip" gate valves, has been published by The Lunkenheimer Company. "King-clip" gate valves are an original Lunkenheimer development, designed to permit disasssembly and reassembly without removal from the line. In addition to this advantage, these valves also feature large drain channels that reduce bonnet chamber clogging in the handling of congealing fluids.

Circle letter (AG) on reply card.

(AH) WASTE PUMPS

Marlow Pumps has just released a new 12-page bulletin on municipal and industrial waste pumps. The new booklet covers features, performance information, specifications, and selection data for plunger sludge pumps, mud-hog diaphragm pumps, and self-priming centrifugal pumps used on sludges and slurries.

Circle letter (AH) on reply card.

(AI) HEAT INSULATION

Owens-Corning Fiberglas Corporation has published a brochure describing Kaylo heat insulation which the company distributes. The publication contains a listing of physical characteristics of Kaylo pipe insulation and Kaylo heat insulating blocks; typical applications, K factors, standard sizes, thicknesses and forms, recommended thicknesses and insulation efficiencies. Publication includes 12 photographs, three graphs and five charts. Kaylo products, made of a compound of lime and silica, are effective to 1200 F.

Circle letter (AI) on reply card.

(AJ) WORM GEARING

Cleveland Worm and Gear Company has recently announced publication of a bulletin on its worm gearing and worm gear drives. The two-color bulletin is illustrated and describes in detail points of importance on Cleveland gear drives and speed reducers.

Circle letter (AJ) on reply card.

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Newark, N. J.—Murray Eskin, Industrial Office Bldg.
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